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Improving Asset Management Through Channel-Partnering in the Commercial PC Market

by

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and the Department of Mechanical Engineering
in Partial Fulfillment of the Requirements for the Degrees of

Master of Science in Management
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Master of Science in Mechanical Engineering

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Abstract

When manufacturing products with base materials that rapidly depreciate through technology advancement, it is in each stakeholders' best interest to minimize the overall amount of inventory in process while maintaining required service levels. In commodity markets, where brand substitution is readily accommodated, the ability to remove any excess costs is a top priority.

The experience of many manufacturing companies indicates that an improved cost position can be established by collaborating with suppliers and distributors to reduce system inventory levels. In this paper, an analysis is completed to show how the concept of channel-partnering can provide considerable benefits to the manufacturers of commercial personal computer products. An intuitive illustration that can be used to help sell the channel-partnering concept is provided. A framework for assessing when it is appropriate to consider channel-partnering is established.

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1. Introduction

This thesis was written based on an educational internship within the Digital Equipment Corporation's (Digital) Personal Computer Business Unit (PCBU). This introductory chapter is intended to provide the reader with a general sense of the overall intent of this paper. Section 1.1 describes one of the major problems facing the PCBU. Section 1.2 provides a description of the goal of the paper. Section 1.3 provides a description of the organization of this thesis.

1.1 Problem

Over the past ten years, the computer industry has gone through dramatic changes. Perhaps one of the greatest changes is that centralized, proprietary main frame processing has rapidly been replaced with decentralized, open standard personal computer (PC) based processing. To cope with this change, computer manufacturers' have either adapted and supported this evolution, or have restricted their offerings to highly focused market segments. To remain a major computer manufacturer, companies have been forced to participate in the PC market. To accommodate this, Digital began manufacturing IBM Compatible PCs in 1991. They approached the market with product offerings in essentially all the major segments.

Participating in all the major market segments is a difficult strategy for any company to complete successfully. The large commercial user segment requires a different marketing approach than the retail consumer segment. The high technology laptop market requires a different approach than the commercial server segment. Supporting direct mail customers requires a different system than that used for dealing with indirect-distribution channels. Digital was attempting to participate in many of these segments simultaneously and had experienced difficulty. During the first week of February 1996, company management announced that Digital was exiting the retail consumer PC market and would be focusing its efforts on the commercial market (Goldberg, 1996).¹

The commercial market is primarily supported by indirect-distribution channels. Recent studies indicate that the distributors of the indirect-distribution channel have a considerable influence on the specific brand purchased by the end user.² The criteria for choice of which brand to recommend is primarily profit margin, with quality and availability being an ante to participate in the market.³

¹ "Consumer" here means the individual home/recreational user.

² Upwards of 77% Influence. See 1995 Desktop Customers Brand Preference Study, by Advantage Business Research for CMP Channel Group.

³ In the same report cited in (2), the top 12 recommendation reasons included these quality elements: (compatibility, reliability, technical support, warranty, ease of maintenance, service support, speed, manufacturer reputation, and ease of installation) and delivery elements: (product availability) and margin elements: (price and profit margin).

When scale economies have an impact on overall profitability, market share is often a critical success factor and therefore a competitive objective for the larger manufacturers. Since distributor profit margins are the difference between the free market price and the underlying product and distribution costs, a manufacturer interested in market share must provide the lowest comparative to-distributor price with an efficient management control system. Manufacturers are challenged to provide the best to-distributor price with an appropriate gross margin for themselves. To maintain its margin, a manufacturer must reduce product development, manufacturing, and marketing related costs as much as possible.

The PCBU finds itself in a very competitive environment that is increasingly difficult to succeed within. It must find a way to grow market share profitably, or be forced to exit the market. The challenge is primarily one of how to decrease costs while maintaining competitive products and services.

Several issues drive the costs of PC demand fulfillment and each manufacturer has been working aggressively to improve them. The majority of these cost reduction efforts have been focused on making business function improvements, such as manufacturing process enhancements, design for assembly, and automated materials management systems. Given the competitive attention provided to these areas, there are few costs that can be improved through a continued functional perspective.

1.2 Goal

This paper is concerned with improving commercial PC product cost by taking a total business process view of demand fulfillment. The concept of channel-partnering for competitive advantage is being advocated. Manufacturers in industries with similar characteristics have adopted channel-partnering with success. There has been some partnering activity in the PC industry, but it has been primarily focused on manufacturer-supplier relationships. The prime thrust of this work is to address the concept of manufacturer-distributor channel-partnerships. A fully integrated supply chain partnership is supported as the ultimate goal.

Although there has been progress in the advancement of integrated supply chain concepts, most of the literature provides only a general conceptual description of the benefits, not one that supports ready adoption. Management can intuitively appreciate the concepts, but an objective study is usually required for support. A channel-partnering value analysis directly related to the commercial PC market has not been completed.⁴

The goal of this paper is to examine the particular appropriateness of applying channel-partnering concepts to the manufacture of indirect-channel distributed commercial PC products. The paper will argue that an improved business position can be established by encouraging behavior in members of the value chain that will enhance the overall competitive posture of each member. The author's intent is to demonstrate how

⁴ If any such study has been completed, the author was not able to find it.

significant costs can be taken out of the process through improved asset management alone. The costs being addressed are those related to inventory depreciation and the opportunity cost-of-capital. Many other cost savings are conceivable, but are difficult to quantify for this purpose of supporting the channel-partnering concept in this thesis.

The target audience for this paper is the general business manager who is concerned with improving business success through cost reductions in markets for rapidly-depreciating, commodity-like products. This manager could be involved in the PC industry, or other industries with similar characteristics such as fashion or fresh seafood.

1.3 Organization

Chapter 2 is primarily for general context establishment. It is used to describe the commercial PC market structure and some key manufacturing management challenges. For logical arrangement, this chapter has been broken down into the three major functional groups: sales, product development, and manufacturing. Each of these functions is treated generically.

Chapter 3 provides an analysis specific to Digital's PC operations to understand the areas of opportunity. Section 3.1 describes the analytical approach that is to be used against a recent, historical business period. Section 3.2 presents the results of this analysis to establish some of the value of channel-partnering in terms of inventory reduction and improved cash management. Section 3.3 provides some general observations related to the overall market that highlights some of the challenges.

Chapter 4 describes how channel-partnering is a management concept that is appropriate to consider for indirect-channel distributed commercial PCs. For illustrative value, descriptions and examples of successful partnerships are provided in section 4.2. Section 4.3 provides a description of some of the core requirements for a successful partnership implementation. Section 4.4 provides a specific description of how partnering should be able to help in the production of commercial PC products. Section 4.5 describes implementation challenges with some proposed generic solutions.

Overall conclusions and recommendations are presented in Chapter 5. Section 5.2 provides the major conclusions of this work. Section 5.3 provides the general recommendations for Digital based on this work. Section 5.4 provides a description of the general applicability of this work, and how the concepts can be extended beyond the commercial PC market. Section 5.5 provides some detailed action items that Digital might complete on a successful channel-partnering implementation program.

Appendix A provides an analysis to help describe the competitive nature of PC manufacturing. Appendix B is included to provide the background and detail for the financial analysis conducted in chapter 3. Appendix C provides some detailed inventory management background.

2. Background

In this chapter, the commercial PC market and general manufacturing environment are presented. The intent of this presentation is to provide sufficient context to help the reader understand the dynamic nature of the business and the fundamental challenges that participation in the market presents.

Section 2.1 describes the commercial PC market to provide a general sense of the environment. Sections 2.2 through 2.4 provide a general overview of the sales and marketing, product development, and manufacturing functions. Each of these is treated in very general terms. It is beyond the scope of this chapter to articulate all of the detail related to the responsibility of each group.

Included in section 2.4.3 are some inventory management concepts. These are presented to enable the reader to appreciate the work that follows in the analysis of chapter 3.

2.1 Commercial PC Market

Due to the open design architecture, and readily available materials and sub-components, the commercial PC market is fiercely competitive. A five-forces analysis indicates that the PC industry is not attractive to participate in (Appendix A).⁵ Virtually anyone can enter this market as a manufacturer with few entry barriers. This has led there to be more than a dozen major players who have varied market shares in their area of focus.

The dynamics of the market have forced the relative position of the players to shift significantly over time. The industry is so competitive that in late February, 1996, the general manager of one of the most respected PC manufacturers was quoted, when discussing the upcoming competition in the PC industry, as saying: "...It is going to be a blood bath. You better be ready." (Burke, 1996).

The commercial PC market includes users from the small-office/home-office (SOHO) category to the Fortune 100 users. These users may require general purpose or high performance, graphics applications intensive, machines. They often have different application requirements and their method of obtaining product varies from retail to direct sales force procurement.

2.2 Sales and Marketing

There are many ways to sell and market a PC. In section 2.2.1, the various distribution models are briefly introduced and the one selected by Digital is presented. With this selected model, there are specific issues related to the business terms and conditions that are described in section 2.2.2. Sales quotas and related targets are briefly described in section 2.2.3. Section 2.2.4 provides some of the management implications of these

⁵ The Five Forces analysis framework was developed by Michael E. Porter to conduct a structural analysis of an industry. See *Competitive Strategy*, pp 3-33.

terms and conditions coupled with the sales quotas and related targets. Based on the power of the distributor to influence the final sale, issues related to advertising, promotion, and related elements have been left out of this description.

2.2.1 Distribution

The distribution channels selected vary by PC vendor and have significant competitive implications. Figure 2-1 represents the general PC distribution structure. Some manufacturers concentrate solely on direct-channels; mail order or direct sales force. Other vendors focus entirely on indirect-channels; retailers or distributors. Some manufacturers use a combination of the methods.

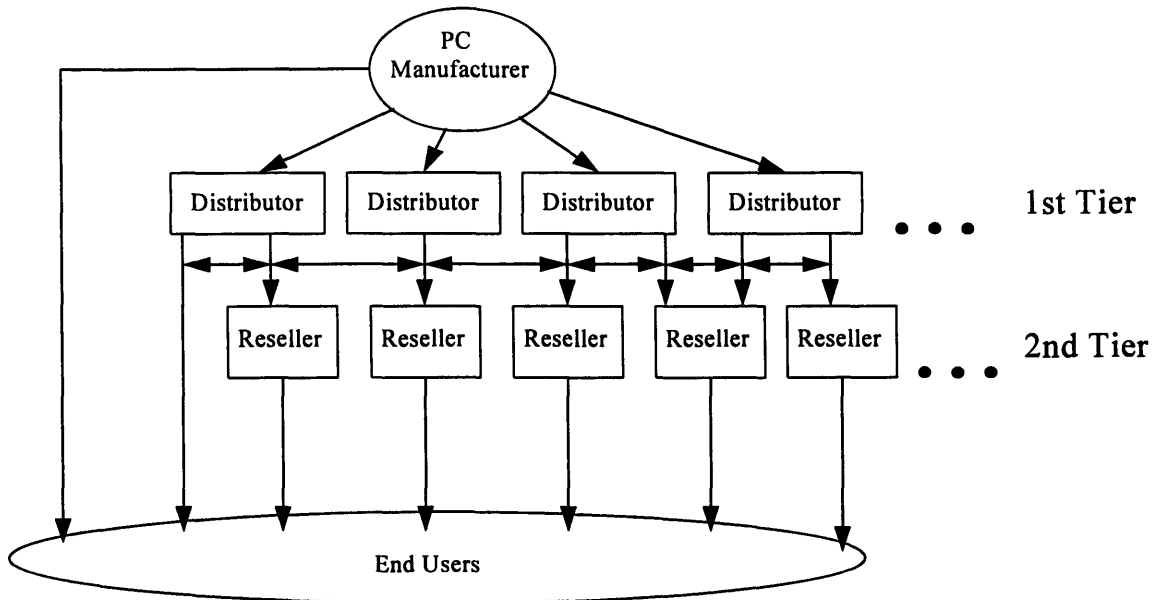


Figure 2-1: General PC Distribution Structure

The reader should note that distributor refers to a class of channel-partners that perform a variety of value-added activities. The same issue applies to the label of reseller. It was not deemed necessary to identify the exact classes of all channel-partners for this paper. The manufacturer can sell directly, with no channel contact, or indirectly, through one or two channel members.

The indirect-method generally deploys a multiple-company distribution system. The industry refers to the structure as a one-tier and a two-tier system. In the two-tier portion of the channel system, the first-tier distributors compete with each other for the business of the second-tier reseller. Some of the first-tier distributors own the second-tier, but the vast majority of the second-tier can buy from anyone they wish. There are generally few distributors to many thousand resellers; this varies by geography. Pretax hardware margins reside in the 2% to 6% range for many corporate resellers and national distributors (Rines, 1996).

As stated in section 1.1, recent studies indicate that the resellers in the distribution channel have a considerable influence on the specific brand purchased by the end user. This high distributor power implies the need to have the lowest comparative costs in order to gain market share by increasing margin for the channel members. This basically means providing the distributor with the ability to take more money between its costs and the end-user market price.

2.2.2 Terms and Conditions

When dealing with an indirect distribution system, a manufacturer will establish business terms and conditions with its distributors. These terms describe how payments will be made, what discounts will be provided, and generally how the relationship will be structured. Table 2-1 lists some terms and conditions with a description of purpose.

Term or Condition	Purpose
Channel Reporting	<ul style="list-style-type: none"> • Understand end-user sales to improve forecasting • Track channel inventories to improve live-cycle management
Co-Op Advertising	<ul style="list-style-type: none"> • Increase sales of product by sharing burden with resellers
Qtr Volume Rebates	<ul style="list-style-type: none"> • Drive sales to goals/forecast to help drive revenue
Price Protection - Channel A/P reduced if inventory is de-valued through price action	<ul style="list-style-type: none"> • Encourage channel member to hold inventory without risk of losing value with price shift. This enables the channel-partner to take more product speculatively.
Product Allocation - total stock is divided among channel members	<ul style="list-style-type: none"> • All channel members have access to some of all products • Reduce channel conflict
Dead on Arrival Returns at X%/Qtr	<ul style="list-style-type: none"> • Protect channel member from poor quality
Inventory Balancing allows for returns of product to adjust levels	<ul style="list-style-type: none"> • Reduce exposure of channel member to product obsolescence. • Encourage product storage
Free Freight for volume	<ul style="list-style-type: none"> • Encourage efficient ordering
Floorplanning - Digital pays X Days interest	<ul style="list-style-type: none"> • Encourage sales by decreasing risk to distributors
Warranty	<ul style="list-style-type: none"> • Risk protection for end-user

Table 2-1: Generic Business Practice Terms-and-Conditions⁶

2.2.3 Quotas and Sales Targets

In general, the sales force is required to provide a forecast of anticipated demand to the business managers. The business managers work with the sales force to establish appropriate quotas, or volumes of sales expected by market segment. The quotas are used

⁶ This list provided in Digital's PC/Reseller business guidelines. Not all information was included, and numbers have been left out to protect sensitive information. NOTE: A/P=accounts payable

to help plan the production management activities such as procurement, capacity management, and related elements.

To help ensure performance, these quotas are also used to set the variable compensation element of the sales and marketing and other staff to provide them with an incentive to meet the plan. The intent of these quotas, and the compensation plans and related metrics, is to encourage behavior that increases the overall company value for the shareholder.

2.2.4 Management Challenges

There is one commonly known problem with this type of sales management system. This problem is often referred to as the hockey-stick effect. If a quota is unrealistic, and it is obvious that the plan is going to fall short, the sales force is motivated to provide incentives to the distributors to buy more products. These incentives are provided by improving the terms and conditions. This process, which effectively pulls orders in from the subsequent business quarter, is termed forward buying.

Forward buying has the effect of surging demand seen by manufacturing at the end of a quarter. It has a secondary effect in that it causes the subsequent quarter to fall short of expectations which ends up forcing the pulling-in of orders from its following quarter. Once this cycle is initiated, it cannot be easily stopped. The overall problem is that this behavior leads to the erosion of profits for both members of the distribution system, and a reduction in the value of the product to the end-user.

Another related management challenge is tied to the impact that a missed plan has on the manufacturing organization. If the forecast does not occur, manufacturing will be left with excess, or inadequate resources to meet demand. Section 2.4.1 will be used to provide a general understanding of why this can have a serious impact on commercial PC demand fulfillment costs.

2.3 Product Development

Since the architecture for an IBM compatible PC is openly available for anyone to use, and has been standardized, the product development issues tend to be more related to cost reducing and life-cycle management than advanced electrical engineering architecture (Cusumano and Selby, 1995). The product developers must be constantly aware of technological advances in the industry and be prepared to match product offerings that incorporate these new technologies. If a product development is delayed, or does not consider the life-cycle management implications, major market share can be lost. Section 2.3.1 provides some more detail about the challenges of life-cycle management. Section 2.3.2 illustrates the effect multiple SKUs has on product management. Section 2.3.3 addresses the subject of differentiation in the commercial PC market.

2.3.1 Life-Cycle Management

Perhaps the biggest product development challenge is related to the management of product life-cycles. The product development cycle time in PCs ranges from 12 to 18 months while the average PC product life-cycle has been reduced to less than 9 months (Gutgeld and Beyer, 1995). With these short life-cycles, any product that is over stocked when there is a model change may become immediately obsolete. Analogous markets include products like perishable food or fashion clothing. If a manufacturer over produces in either of these markets, it can lose considerably in terms of obsolescence related product markdowns.

A good illustration here is made by considering what would happen if there were excess inventories in the distribution system when a major product color change is made. This would be the situation if the color of the PC and all related components is changed from yellow to beige, or some other color. If the new color becomes immediately accepted and sought after, the inventory of the older color is put at risk. Effective life-cycle management includes taking these factors into account when making major model changes.

2.3.2 SKU Management

Another major product development issue is that of stock keeping unit (SKU) management. An SKU is a product variant that is distinguished from other variants by the components that comprise the system. Successful product management requires that the finished PC be compatible with popular third party hardware and related applications. The product manager will test these options to list them as acceptable variants. These options must be made available or the platform will not be received well in the field.⁷

Listing the acceptable options is one element, another challenge is related to the actual production of the numerous combinations that can be made from all of the options. Taking a base unit and converting it to a completed product that is different by the type of options installed is referred to as SKU proliferation. The issue of proliferation is a considerable manufacturing challenge.

This SKU proliferation could be done in the factory, either speculatively to a forecast or built directly to an order. As will be illustrated in chapter 3, if the proliferation of variants is not reduced, or adequately postponed, excess finished-goods inventory can accumulate. These excesses exacerbate the obsolescence issue described in section 2.3.1.

To provide an example of SKU proliferation, two specific SKUs will be used. Digital sells a part that will be referred to as part F. Part F is made by combining the following parts: a high profile chassis, a 90 MHz CPU on a main logic board, a keyboard, a 1 gigabyte disk drive, a 3.5 inch floppy drive, and 32 megabytes of random access memory. Part G has the exact same configuration with the exception of 16 megabytes of random

⁷ Digital management interview. One product manager emphasized the significant challenges that this presents.

access memory. If a customer is looking for Part G, and all the distributor has are the F parts, a sale could be lost.

The fundamental reason that SKU proliferation can cause an increase in inventory is related to establishing safety stock to manage the variability of demand. As will be shown in section 2.4.3.1 inventory is often held to buffer against variability in demand for a product, or the variability in the lead time to replenish the item. Since the variability in demand for the raw materials is less than the variability in demand for the proliferated SKU, it is often a good policy to postpone configuration of the SKU until the actual demand is known.

Figure 2-2 can be used to present the concept of SKU proliferation. In this illustration, parts A and B could represent a high and low profile chassis. Parts a and b could represent two different main logic boards. Parts i, ii, and iii could represent three different disk drives. From this representation, the reader will note that the combination of 7 parts can lead to 12 SKUs. The basic number of variations for each element are combined and then the total number of each element are multiplied by each other to provide this final SKU number. This illustration has not included all the possible categories such as software, monitors, and CPUs.

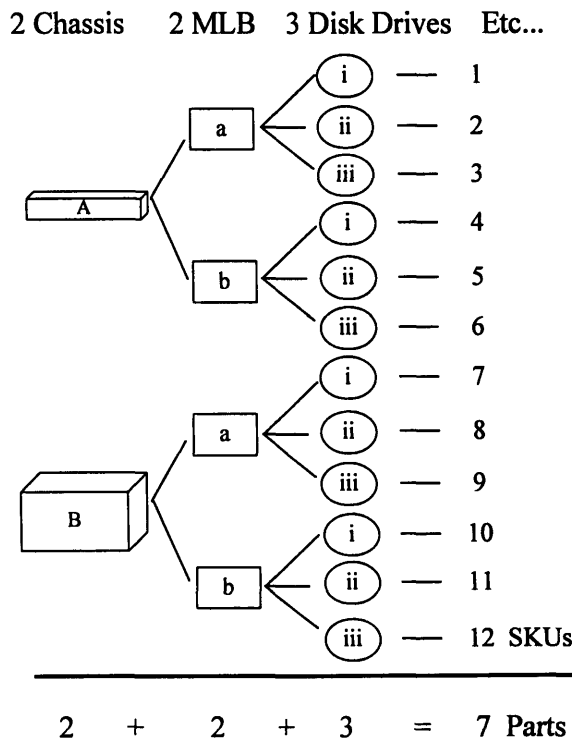


Figure 2-2: SKU Proliferation Illustration

2.3.3 Differentiation

The final major element related to product development surrounds the differentiation options in the commercial PC market. To many customers, a PC is a PC. There are very limited areas to differentiate. While there are some niche opportunities related to

changing colors, or incorporating flashy features in a notebook PC, most of these are fashion-oriented and can lead to rapid obsolescence. There are considerations for differentiation on service with getting-started manuals and related elements, but in general, PC products can be characterized as commodities and therefore force the competition to be on cost and brand image (Porter, 1980).

There are few things that a commercial desktop PC vendor can do to reduce the costs of a product design for comparative advantage. With the use of competitive tear-down analysis, it is rare that any differentiating advancement in a commercial desktop design is not immediately incorporated into a competitor's product. Given this, the management objective should be to work aggressively to identify how to reduce systemic business process costs.

Also important to note, as an element that limits differentiation, is the standardization of technology. With open standards, manufacturers are limited in their ability to establish a differentiation based on a product feature that may otherwise provide an advantage. For example, if Digital were to come up with a better data transfer architecture that clearly differentiated itself, users may not adapt it since it could be incompatible with other mating methods.

2.4 Manufacturing

In this section, the manufacturing process is presented in general terms. Section 2.4.1 provides a description of the procurement function. Section 2.4.2 provides a description of the general assembly operations and related challenges in terms of cost, quality, delivery and flexibility. Section 2.4.3 is included as for a detailed appreciation of why inventory is required, with a focus on finished-goods inventory management.

2.4.1 Procurement

Like the distributor who purchases a PC from a manufacturer, the manufacturer of the PC will face similar challenges when purchasing materials and sub-components. The challenges, in general, are related to: the management of lead times, the benefits of scale, the use of the gray market, and the overall relationships between supplier and customer. These elements are generally presented in this section.

2.4.1.1 Lead Time

Component manufacturers can quote lead times of up to 5 months for their products (Gutgeld and Beyer, 1995). Not all the suppliers have the power to put the burden of high lead times on the manufacturer. These less powerful suppliers will be facing the same overstocking issues that the manufacturer sees when there is a slowdown. Due to rapid technology advancements, it is difficult to provide forecasts with the degree of certainty required to efficiently manage materials with these long lead times.

The procurement and material managers must buy components in preparation for forecasts that have been established when the sales quotas were established. This process

works as long as the quotas are met, but when they are not met, as was occurring with the early 1996 PC glut (Choi, 1996), excess costs develop. Section 3.2.2 illustrates this issue.

2.4.1.2 Scale Economies

The general issue here is related to the benefits of buying large quantities to receive price benefits. Price benefits are normally extended when items are bought in large quantity since transaction processing costs are lower than multiple purchases. Price benefits related to bulk purchasing can be substantial in the PC industry.

2.4.1.3 Gray Market

Materials can be bought from suppliers based on forecasts, but due to the potential for a shift in market interest, significant risk is gained by doing so. An alternative approach is to buy a conservative volume that is known to be within the planned production and to source any additional material on the open, spot, or gray market.

Many supplies can be procured from this gray market. This is the case since manufacturers and producers often stock parts speculatively and end up with excess inventories that force discounted sales. The price benefits for a purchaser can be substantial. One problem related to this is the ability to gain access to scarce components that are put on allocation when a particular technology or core component is in very high demand. This is where inventory hedging is conducted, which reinforces the gray market. Gray market related procurement is a game of variances. Sometimes a manufacturer wins, sometimes not.

Another problem with gray market procurement is related to the actions taken by the original material supplier. For many economic reasons, these vendors do not want this type of procurement to be conducted. They therefore refuse to provide a warranty for their product if it is bought this way. Large manufacturers cannot afford to manage this additional complexity and are therefore relegated to procure the parts speculatively to forecasts from the original vendor.⁸

2.4.1.4 Supplier Partnerships

A recent trend in PC manufacturing is the establishment of partnerships with material suppliers. Given the depreciation of raw material inventory, most manufacturers are looking to this as a way to eliminate, or significantly reduce risk. This has led to an extensive interest in line-side-stocking, consumption-based-replenishment inventory control. This control is basically a system where the material vendor essentially consigns the inventory to the manufacturer to use in its products. The manufacturer will not take ownership of the part until he pulls it from the stocking rack. The supplier will see the status of the stock and automatically replenish it as required.

Compaq computer is one of the leaders in these supplier-manufacturer partnerships. In fact, many of the key PC material suppliers have set up production or distribution centers

⁸ Digital management interview. A purchasing manager conveyed this as a significant challenge in this market.

in the Houston, Texas area to support Compaq's PC manufacturing operation. Digital and many other major PC manufacturers are establishing similar relationships with their suppliers. The problem is that this risk reduction often requires a slight price premium, or the supplier may only be willing to do this when it is a buyers' market. When the market becomes a sellers' market, the prices could increase (Carbone, 1995).

In order to maintain a reasonable price for this risk-reducing service, the materials vendors need information. They will be conducting similar inventory management analysis to what the PC manufacturer uses. Without having reasonably managed demand and variability information, this type of arrangement will not be very beneficial.

These supplier-manufacturer partnerships are often looked at as a way to reduce the risk for the member with the most power in the value-chain. When Compaq initiated the co-location with their partners, one of its prime objectives was to reduce warehouse inventory. It is not clear that its interests were in actually helping suppliers reduce their risk (Bivins, 1995).

Whether a manufacturer has good intentions is not the only issue. Another major issue is whether there is a way for the members of a value-chain to work together to improve their combined competitive position. Chapter 4 provides some detail on the overall concept of channel-partnerships.

2.4.1.5 Internal Suppliers

An interesting issue that highlights the value of information management nicely is the management of internal suppliers. Internal suppliers, who have access to the information that their internal customer uses, can often plan production and related capacity. Digital has used this information, along with the knowledge that demand is historically skewed through-out the quarter, to make trade-off decisions related to building inventory ahead or investing in capital to satisfy actual orders (Colgan, 1995).

The problem with this inventory/capacity tradeoff approach is that it works to manage efficiently given that this end-of-quarter skewed demand exists. An alternate approach would be to determine if the skew is real and working to remove the underlying causes if it is not. A truly effective supplier-manufacturer partnership will be one that works to provide the actual end-user demanded product when it is needed, without excess inventory.

2.4.2 Assembly

A commercial PC has common basic elements; chassis with power supply, main logic board, central processing unit (CPU), hard disk drive, monitor, keyboard, software, memory and other components.⁹ Figure 2-3 provides a general depiction of the complexity. PC assembly requires the obtaining and organization of materials, the scheduling and assembly of the PC, the installation of factory installed software, the

⁹ All possible components are not listed. This list should be used for a general appreciation of the complexity.

testing of the completed PC, and the packaging. It is a straight forward process that often takes less than eight hours with simple capital and manual operations.¹⁰

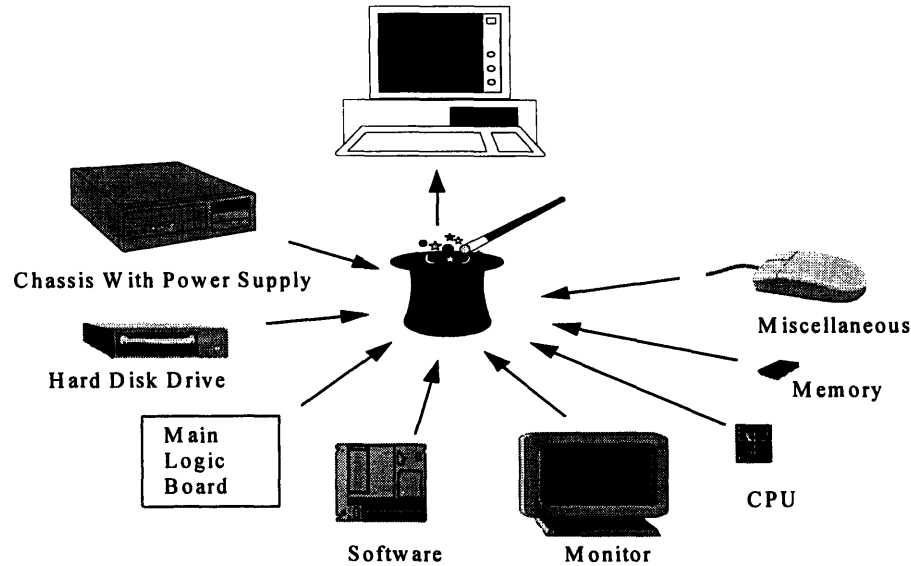


Figure 2-3: Generic PC Manufacturing

For production management, manufacturers can speculatively build systems to a forecast and distribute when ordered. Another approach would be for them to build and distribute to an order. And finally, they could build base systems ahead and postpone the configuration for themselves, the distributor, or the end user to complete when desired.

Digital predominantly uses a build-to-order (BTO) assembly process. With this process, a PC is not constructed until a firm order is received from a channel member. As illustrated in section 2.3.2, and will be further illustrated in section 2.4.3, this BTO practice has some major cost benefits related to SKU postponement.

Since a common way to describe a production system is to consider cost, quality, delivery and flexibility issues, they will be described here to provide a general understanding of the overall manufacturing environment.

2.4.2.1 Cost

Actual product costs are not easily determined in a complex system like that used by Digital. There are several ways that costs have been accounted for and the information is not readily extracted and collated between functional groups. In an attempt to convey the costs in a PC, the concept of relative costs as a percent of net-operating-revenue (NOR) will be used since this information was readily available. For this paper, the more intuitive cost analysis framework of gross margin improvement is used in chapter 3.

¹⁰ Digital Management Interview: To build and test a PC normally requires less than eight hours.

The manufacturing costs are shown in Figure 2-4. Here the cost components are broken down into percentages of NOR. In this figure, it can be seen that materials of a PC make up between 70 and 85% of NOR. Also presented are the relative size of the remaining NOR allocation. This representation conveys that the actual costs associated with manufacturing capacity and production, shown as Assembly, are typically very low.

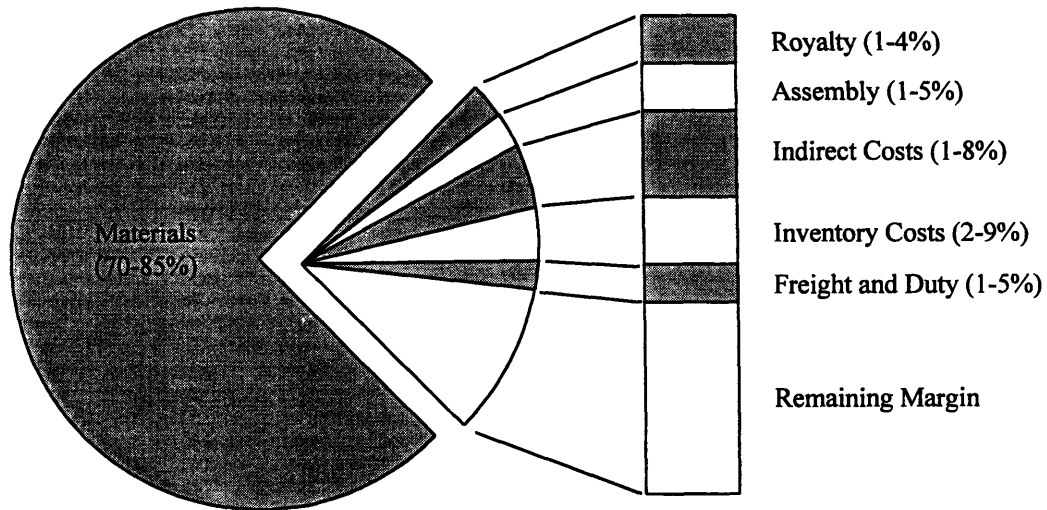


Figure 2-4: Costs as Percent of Net-Operating-Revenue

Table 2-2 provides a breakout of the drivers for each cost bucket. From this table, it can be interpreted that a significant cost reduction opportunity may be in the area of inventory management. With this figure, it is important to realize is that the drivers listed are the commonly understood drivers, and not necessarily the systemic root causes of the costs. It must be emphasized that although this method provides some general insight, it does not capture all the costs of doing business such as those conveyed in section 2.2.2.

The costs not included in the NOR representation are the costs that take the original sales revenue down to a net revenue. For example, for corporate cost allocations reasons, the cost of warranty has been taken out of the original revenue number. Also removed were any discounts and related pricing actions initiated by the sales and marketing organization for sales related activities. This detailed information is not readily extracted with Digital's current management accounting systems.

Cost Bucket	Relative Significance	Drivers
Materials	70-85% of Revenue	<ul style="list-style-type: none"> • Volume or Scale • Product Design • Buying Arrangements • Forecast Reliance
Freight & Duty	1-5% of Revenue	<ul style="list-style-type: none"> • Partial Containers • Long Distances • Lack of Local Source • Rush Shipments • Inventory Balancing
Inventory Costs	2-9% of Revenue	<ul style="list-style-type: none"> • Obsolete Inventory • Depreciation & Shrinkage • Returns Management • Speculation or Hedging • Insurance • Storage Warehouses
Indirect Costs	1-8% of Revenue	<ul style="list-style-type: none"> • General Staff • Engineering • Materials Acquisition • Product Management
Assembly	1-5% of Revenue	<ul style="list-style-type: none"> • Capacity (HR and Equip) • Facilities • Training
Royalty	1-4% of Revenue	<ul style="list-style-type: none"> • 3rd Party Software

Table 2-2: Cost Drivers¹¹

2.4.2.2 Quality

Here, quality includes: reliability, durability, technological features, customer services and aesthetics. The quality of a commercial PC is similar among the top manufacturers (Furger, 1995). In general, the issue of quality is more related to perceptions of quality as opposed to actual performance. Some quality differentiation can be made in terms of service and ease-of-use.

2.4.2.3 Delivery

Delivery is a complicated issue in the PC industry. Retail shoppers most often want the PC there when they go looking for it. If it is not there, they will often readily switch brands. For this reason, manufacturers participating in the retail consumer market often limit the number of SKUs and hold considerable finished-goods inventory in their distribution channels. Due to the seasonal demand of retail buyers, and the associated capacity and inventory tradeoffs that must be carefully managed, the retail market provides different challenges to manage than the commercial PC market.

¹¹ This information came from Digital. The actual numbers for Digital have not been provided to protect proprietary information. The relative size of the buckets are important. The analysis of Chapter 3 illustrates why.

The direct mail and the distributor-supported users have slightly different delivery requirements than the retail buyer. The sale is not obviously dependent upon the PC being in stock at the instant of the interaction between the buyer and seller. PC customers in these markets may actually allow enough time to meet the demand from production, thus reducing safety stock.¹²

Given any additional order-fill freedom, and the fact that the actual production and shipping lead time is often less than one week, these markets can potentially be supported with much less safety stock than if it is assumed that the order must be met within the week it is generated.¹³ Since individual consumers can buy this way, the direct mail supported commercial category will show some seasonal demand patterns which challenges the build-to-order concept in many of the same ways as the retail segment.

2.4.2.4 Flexibility

Flexibility is concerned with the ability of a manufacturer to respond to market changes. These changes can be related to product or demand-related attributes. Given the short product life-cycles, and variations in the weekly order patterns that can be over 500% (see Figure 3-1), it appears that this is an critical element in this industry. “Appears” is an important distinction since, as will be shown in section 3.2.1, the variability of demand that the factory sees may or may-not be real.

The ability to manage multiple SKUs also plays a role in maintaining a high degree of flexibility. Production processes and equipment must be flexible enough to accommodate the differences in each SKU. The manufacturing processes and equipment must be appropriate for the given level of flexibility desired.

2.4.3 Inventory Management

One particular cost issue that will be highlighted is the rapid depreciation of the value of PC components due to technology advancement. The CPU price change graph, Figure 2-5, highlights the predictable and substantial quarterly markdowns of component materials. Similar price change graphs can be generated for disk drives, memory, and other generic PC components. All of this accentuates that in a market that has rapidly-depreciating products, it is undesirable to hold inventory anywhere in the system. Whoever owns-and-holds it loses real value.¹⁴ It is for this reason that it is imperative to look for and reduce inventories. Any products or materials that accumulate should be scrutinized.

¹² The author was not able to find data to determine this freedom. This is clearly something that management must consider when establishing safety stock and control policies.

¹³ Digital management interview: Most PC customers, anywhere in the world, can be served within five days from strategically located production facilities.

¹⁴ “Owns-and-holds” is an important combination. Due to the manufacturer-distributor terms-and-conditions, just because a member holds the inventory does not immediately imply that he owns it.

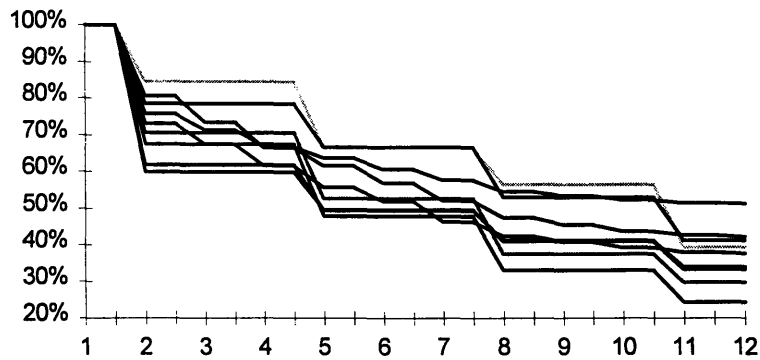


Figure 2-5: CPU Price Percentage Drops Over a 12-Month Period¹⁵
 (Each Line Represents an Individual CPU Variant)

If finished-good PCs are looked at specifically, the actual depreciation is lower than the CPU-based depreciation since not all the components depreciate as rapidly. As illustrated in the graph of Figure 2-6, in a six month period, the average completed desktop PC depreciated at a rate of 3-5% per month in standard cost terms.¹⁶ In a recent report, McKinsey and Company estimate that the rate of depreciation is more on the order of 7% per month (Gutgeld and Beyer, 1996).¹⁷

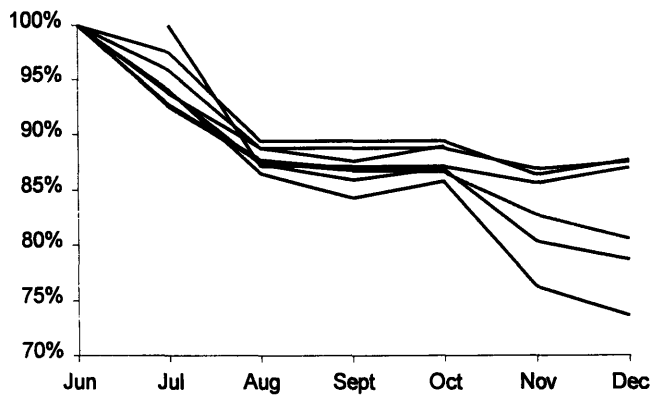


Figure 2-6: Finished PC Standard Cost Percentage Drops Over 6 Month Period¹⁸
 (Each Line Represents an Individual Commercial PC Variant)

To illustrate the issue succinctly, Figure 2-7 can be used to convey the relative value of a finished PC in inventory over time. This relationship has been developed based on the

¹⁵ Source: Digital proprietary records. Numbers have been normalized to disguise sensitive information.

¹⁶ This number is actually conservative since with shorter product life-cycles there is a greater tendency to be forced to heavily discount older technology products to move them from inventory.

¹⁷ 7% established based on 50% reduction in seven months.

¹⁸ Source: Digital proprietary records. Numbers have been normalized to disguise sensitive information.

7% monthly depreciation and the opportunity cost-of-capital. Based on this, and the fact that competition forces the operating margins to be low, one of the highest priorities should be to maintain the minimum level of inventory that will enable the firm to meet its competitive objectives.

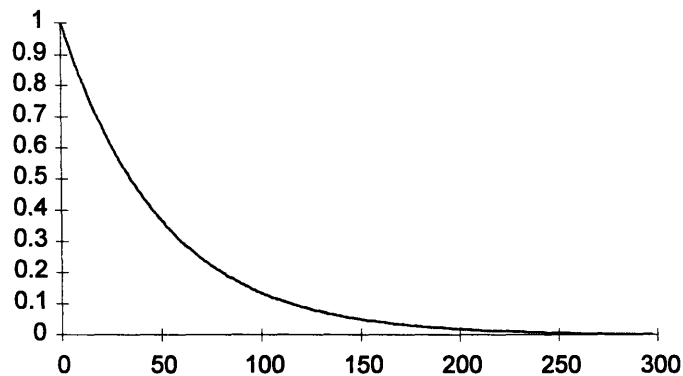


Figure 2-7: Relative Value of a PC in Inventory Over Time
(Relative Value on Vertical Axis. Weeks on Horizontal)

For the purpose of illustrating the overall inventory accumulation drivers, section 2.4.3.2 considers finished-goods inventory. This section, combined with Appendix C, will be used, to establish a general equation representing the approximate amount of finished-goods inventory in the system.¹⁹

2.4.3.1 Buffer Against Variability

Inventory has a purpose, to buffer against variability in lead time, demand, and performance of the production system. The use of inventory was recently summarized by Dr. Stan Gershwin in response to questions on why the complete elimination of inventory by some manufacturers is not optimum: “They get rid of the in-process inventory without realizing what its function is supposed to be, which is a buffer to reduce disruptions by reducing the propagation and influence of one machine’s failure on another machine” (McCormack, 1996). His reference to machine could easily be extended to transportation systems and other transaction processing elements of PC demand fulfillment.

Materials managers will use variability information to establish adequate inventories to buffer against the variability. There are several factors that should be considered when establishing these inventory levels. Appendix C provides some detail on this subject. It was beyond the scope of this paper to establish specific levels of inventory for Digital. This appendix provides the general relationship that will be used in chapter 3.

¹⁹ Understanding the outbound finished-goods inventory will lead to an understanding of the inbound inventory since one manufacturer’s inbound inventory is another manufacturer’s outbound inventory.

2.4.3.2 Finished-Goods Inventory

There are five major categories of finished-goods inventory: staging, transit, cycle stock, safety stock and obsolete. There are eleven major issues that impact the level of these inventories in the system (Magee, Copacino & Rosenfield, 1985):

1. Inventory holding costs
2. Stock-out costs
3. Service level reliability
4. Number of SKUs
5. Number of stocking points or warehouses
6. The overall replenishment lead time
7. Rate of obsolescence
8. Transaction processing economics
9. Coordination of distribution activities
10. New product activities
11. Customer returns

All of these elements can be combined to establish the fact that the finished-goods inventory in the system is a function of cycle stock, safety stock, transit stock, and general management elements. Appendix C provides this concept in detail with a generalization based on some liberal assumptions for illustrative purposes. Also included is a description of each of these five categories. The purpose of including them is to point out that there are many factors contributing to inventory levels.

2.4.3.3 Other Inventory

Additional categories of inventory include work-in-process (WIP) and raw material (RM). The management of these will be based on the same issues presented in section 2.4.3.2.

WIP inventory will be for product that is being processed to satisfy a specific order, or to buffer against variability in a production line. RM inventory will be established based on essentially the same characteristics that finished goods inventory was based on since it is the finished-goods inventory of the supplier.

3. Analysis

From an initial observation of the commercial PC market and manufacturing environment, it might be interpreted that there is no way to improve on the demand fulfillment process. In this chapter, analysis is conducted to demonstrate that there is actually a major opportunity for improvement.

In section 3.1 the analytical approach used to help determine areas of opportunity is described. Section 3.2 provides the results of the analysis. Section 3.3 provides some general observations.

3.1 Approach

In this section, the approach used to determine the areas of opportunity is provided. Section 3.1.1 provides the scope of the analysis. Section 3.1.2 provides detail on the method that was used. Section 3.1.3 provides a list of some of the key assumptions.

3.1.1 Scope

The analysis is restricted to the indirectly-distributed commercial desktop/side product family. The work was limited to one geography, Atlantis.²⁰ The work was further limited to look at the aggregate product demand in an attempt to identify gross system inefficiencies.²¹ The analysis is intended to present an argument for the value of implementing partnerships for cost reduction through improved asset management. This work is not intended to answer all the relevant questions nor perform the detailed quantitative structural analysis.²²

Issues related to determining the value of internal manufacturing as opposed to completely outsourcing manufacturing to third party distributors were not addressed in this paper. For the purposes of this work, it is assumed that a base level of PC assembly within Digital is strategically warranted. The specific level has not been specified since this is also considered to be beyond the scope of this work.

For simplicity, detailed analysis is conducted by looking solely at the potential improvements related to the manufacturer-distributor relationship. The analysis considers only the cost-of-capital and depreciation-costs against any excess finished-good inventories. Many additional costs are left out of the calculations such as; detailed returns processing costs, manpower reduction opportunities, factory capacity utilization benefits,

²⁰ Fictitious competitive geography used to conceal the actual one analyzed.

²¹ Aggregate here means the lumping of all commercial desktop/side products into one demand number. This is a simplifying assumption. Conducting an analysis based on SKU level would complicate the analysis without providing any additional conceptual benefits.

²² In general, the scope was limited to make the analysis feasible. A detailed analysis was not warranted.

freight cost reductions, supply side benefits, and general administration or transaction processing related elements for all the members of the value chain.²³

3.1.2 Method

A recent, historical two quarter demand fulfillment period for Digital is analyzed. The demand seen by the factory is compared to actual end-user demand. Inventory trends are noted and observations are made. The overall intent is to roughly identify the gross margin savings opportunity that can be provided through a modification of the current operating policies. Here, gross margin savings are the minimum gross margin required to carry the inventory with a break-even financial position. To identify this opportunity, the major costs considered are restricted to those of inventory depreciation and the opportunity cost-of-capital.

3.1.2.1 Discounted Cash Flow Analysis

To determine the relative gross margin savings opportunity, a discounted cash flow analysis is conducted. The cost savings benefits are captured in terms of gross margins required to provide the same relative net present value (NPV) with varying inventory levels. The analysis considers only the cost-of-capital and depreciation-costs against any finished-good inventories.

While it is conceivable that the additional cost savings are considerable, the partnering benefits are primarily determined in terms of decreasing the minimum gross margin required which should increase the net margin for the manufacturer. This improved margin can then be shared with the suppliers, distributors and end-users to increase the channel profit margins. By managing this increase in profit margins, market share for the partnership can be increased which should further increase profitability.

3.1.2.2 SKU Proliferation Analysis

The results of the procedure described in section 3.1.2.1 will provide the general costs associated with each week of inventory in the distribution channel. Additional analysis is required to identify potential drivers of inventory. For this purpose, the concept of SKU proliferation is addressed.

A brief analysis of the SKU demand history is conducted to identify and articulate specific anomalies. Inventory reductions related to the number of warehouses, number of SKUs, and overall service level are considered to articulate the general value of reducing each of these elements.

²³ These costs have been left out for lack of a detailed understanding. They can be included to provide an argument that this analysis is conservative.

3.1.3 Assumptions

There are a few assumptions that have been made to support this analysis. Most of these are intended to provide a first order approximation of the benefits of partnering. These assumptions are provided in this section.

3.1.3.1 Monthly Depreciation Rate

One of the foremost assumptions is related to the use of 7% monthly depreciation for completed PC products. As was indicated, this number came from the Gutgeld and Beyer report. The important issue that should be highlighted here is that this number does not appear to be consistent with the price protection and related discounting that most manufacturers have used in the past. What is important is that this is close to the actual change in underlying product costs. Whoever can track these changes the most effectively, with price changes, will have an advantage relative to the rest of the market. A manufacturer who builds to order with no inventory exposure can gain this benefit.

Related to this 7% constant depreciation is the fact that the actual product component prices drop the first month of the quarter, just after the channel is stuffed with inventory. What this indicates is that the effective depreciation is higher than the 7% claimed. The calculations use this 7% constant number. Given this simplification, the actual margin savings stated will vary from the stated percentage per week of inventory reduced. This assumption provides a reasonable estimate to convey the overall value of the concept of channel-partnering in this type of market.

3.1.3.2 FIFO Inventory Management

Another assumption related to the one in section 3.1.3.1 is the overall issue of inventory management. The 7% number used assumed a first-in-first-out (FIFO) management. This concept is used to ensure that the oldest product is sold first; just as if it was milk being sold at a convenience store. There are many challenges related to ensuring that FIFO management happens. It is beyond the scope of this paper to address these directly.

3.1.3.3 Consigned Distributor Inventories

Also related to this FIFO issue is the days-sales-outstanding assumption described in Appendix B. Here it is assumed that due to the terms-and-conditions, the manufacturer essentially owns the distributor-located inventories. This challenges conventional wisdom since the manufacturer does claim the sale as a revenue when the product ships. To simplify the overall analysis, and to accommodate the distributor terms such as price protection and discounting in aggregate form, this simplification was used.

3.1.3.4 Distributor Power

An assumption has been made that the end-user substitutability reports and other industry channel-management reports are truly representative of the marketing environment. Since the author was not able to work directly with channel members, much credence has been given to the value of the statements contained within the reports. If this assumption

is invalid, the ability of the manufacturer to demonstrate goal-compatibility may be more difficult.

3.1.3.5 Minimum Sales Continue

The analysis conducted is based on an assumption that any actions initiated will maintain the current sales volume as a minimum. This is realistic since partnering should actually provide an incentive for the distributor to sell more of the manufacturer's products. If the sales increase, the benefits should be greater than the analysis indicates.

3.1.3.6 Replenishment Lead Time

For simplification, a lead time of 1 week has been assumed. This implies that stock can be replenished within one week. If the actual lead time is greater, the system will be further complicated. This simplification has been made since the exact business improvement numbers are not important, and Digital management indicated a five day order fill capability for almost anywhere in the world.

3.1.3.7 Normal Distribution

For the inventory driver analysis of section 3.2.2, an assumption of normal distribution for demand is made (see Appendix C). This assumption goes further to assume that segregating the aggregate demand into proportions as the number of SKUs and stocking points are increased will provide smaller distributions, but they will also be normally distributed. This simplification is provided for a general appreciation of the impact that SKU proliferation and the number of distributors could have on inventory levels.

3.2 Results

In this section, the results of the analysis are presented. In section 3.2.1, inventory management is shown to be a major consideration. Section 3.2.2 provides some of the potential causes of inventory buildup. Section 3.2.3 establishes a method to consider the overall costs in gross margin terms.

3.2.1 Production Versus Actual Sales

The first thing completed was the collection of data for factory production and actual sales to end-users. For factory production, the shipments per week are captured. For end-user sales, the sales reported out of the distribution channel are captured. The patterns are observed and compared.

When the actual aggregate shipments per week from the production facility are observed, Figure 3-1, the quarterly hockey-stick, or end-of-quarter skew activity is apparent. Due to this, the production facility is forced to manage a demand that is highly variable. For the

two quarter period, the mean demand was 1376 with a standard deviation of 737.5 PCs.²⁴ In this figure it is difficult to determine if the business is growing or not.

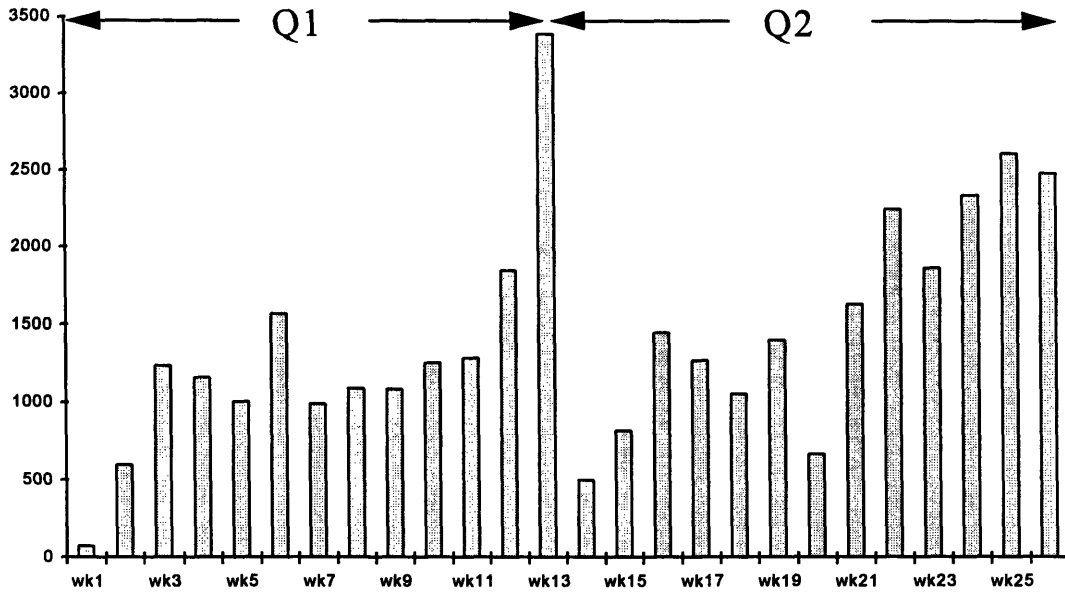


Figure 3-1: Total PC Shipment to the Distributors by Week (Mean=1376, Std Dev=737.5)

When the corresponding weekly sales to end-users are observed, Figure 3-2, the actual sales to end-users are much more predictable and consistent. Here, the mean demand was 752.3 with a standard deviation of 170.6 PCs.

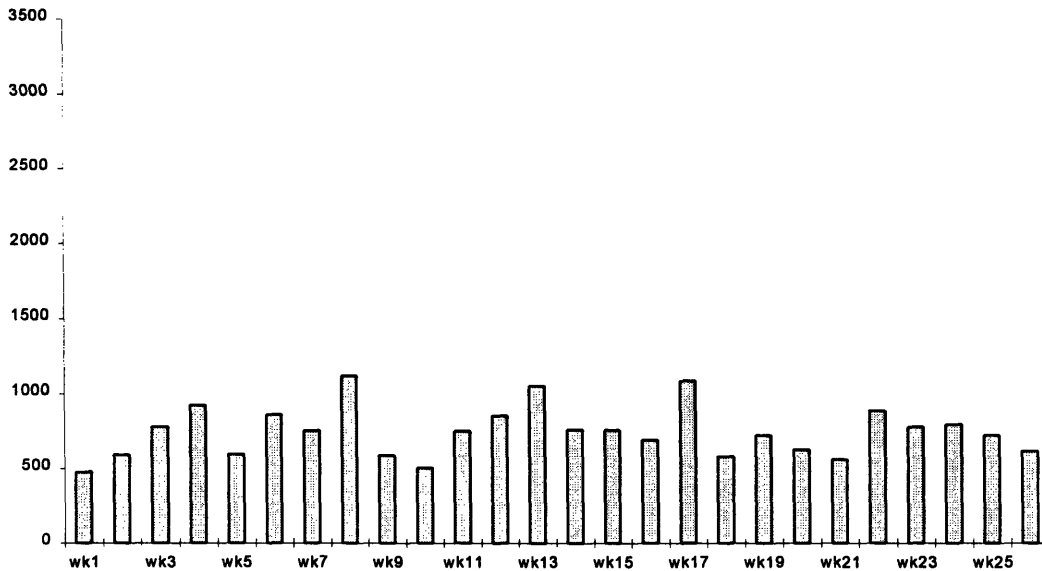


Figure 3-2: Total PC Sales to the End Users by Week (Mean=752.3, Std Dev=170.6)

²⁴ The data displayed in this section are not the actual magnitudes; they have been disguised to protect confidentiality while reflecting the correct proportions.

When the sales into the distribution channel are superimposed with the actual sales out of the channel, Figure 3-3, it appears that not only was the end of quarter skew an artificial demand, but the sales into the channel were actually exceeding the demand. When the total average shipments and total average sales are included, the fact that the production was exceeding sales on the order of 2 to 1 surfaces.

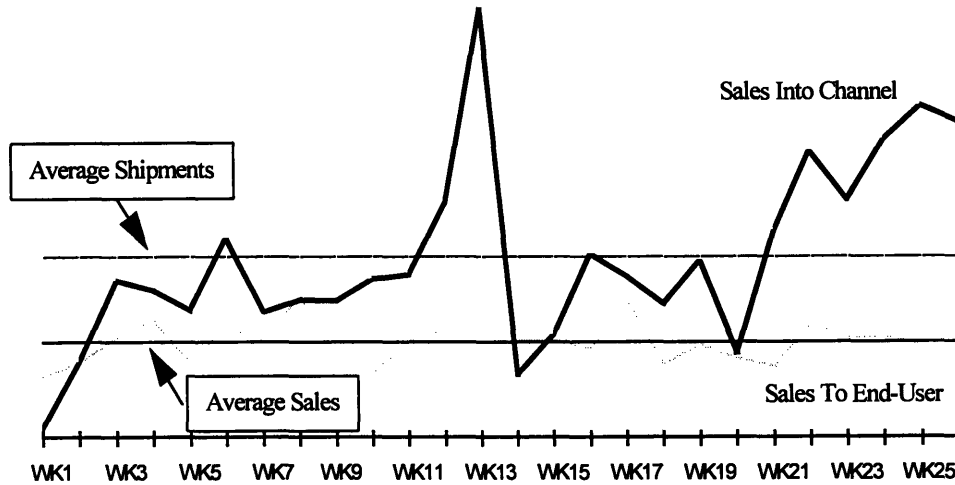


Figure 3-3: Sales Into the Channel and Sales To End-User Superimposed

This pattern implies that inventories were building somewhere. The cumulative finished-goods inventories are plotted in Figure 3-4. The cumulating inventory alone, never mind what the period started with, is approaching 18,000 PCs.²⁵ When the actual average weekly sales of 752.3 units are considered, this inventory accumulation works out to be approximately 24 weeks worth of sales.

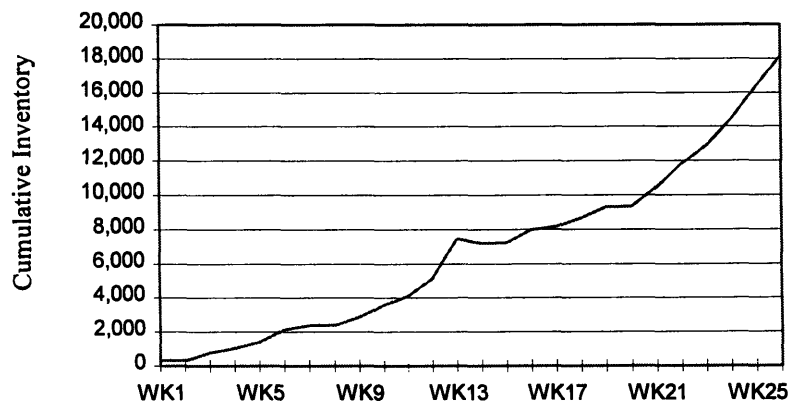


Figure 3-4: Finished Goods Inventories Shipped and Not Sold to End Users

From the section on inventory management, 2.4.3, the reader should have an appreciation that this is not the ideal situation. There must be a reason for this happening. Section

²⁵ For this accumulation, it was assumed that there was enough inventory on hand week one to support one weeks worth of actual sales (752 PCs). These numbers are also disguised numbers to protect sensitivity.

3.2.2, is used to address this issue. Section 3.2.3 provides an analysis of the cost implications of this inventory, and what the potential benefits of reduction are.

3.2.2 Inventory Buildup Causes

There could be a logical reason for there to be 24 weeks worth of finished product in the distribution system. To illustrate what the reasons could be, Equation 4 on page 90 will be used for illustration in sections 3.2.2.1 through 3.2.2.3. The prime element of the equation that will be considered is the second term. This is the safety stock term. Since this equation was established as an approximation, the exact relationship will not be known. What can be established from this equation is a general sense of the probable drivers of inventory.

In section 3.2.2.4, the other terms in the equation are generally addressed. In section 3.2.2.5, the root cause of the inventory accumulation is proposed. A general comment on the perceived benefits of a BTO process are presented in section 3.2.2.6. A summary of this possible inventory buildup causes is provided in section 3.2.2.7. _

3.2.2.1 Service Level

One of the first things to consider is the service level required or requested at each distributor.²⁶ Figure C-3, shows that an increase in this service level will increase the inventory required rapidly, perhaps this is the main driver. However, if this is considered the only inventory element, and the assumption of the demand being normally distributed is applied, the impact of this should be not much more than 4 times the standard deviation of demand. Since this standard deviation was 170.63, the associate inventory impact would be approximately 580 units. This taken by itself represents less than one weeks worth of demand.

A potential source of error with this logic could have to do with the demand being very different than normally distributed. Section 3.2.2.3 addresses this issue in more detail.

3.2.2.2 Number of Distributors

Equation 4 indicates that the number of warehouses increases the safety stock by the square root of the number. Since a distributor holds the inventory speculatively, they could be considered warehouses for this purpose. Figure C-1 provides the approximate relationship. Since it was beyond the scope to determine the number of distributors, the exact number is not known.

Since the exact number of these was not known, it will be set to 50 stocking points. The square root of 50 times the 1 week approximated in section 3.2.2.1 can be combined with the equation to establish the approximate inventory level of 4,100 units. This represents less than 6 weeks worth of demand.

²⁶ The author was not able to determine what these were, or whether these were even established.

3.2.2.3 Number of Stock Keeping Units

The inventory equation indicates that the requirements increase by the square root of the number of SKUs also. Since 257 different SKUs were sold in this total period, this number will be used. By applying the relationship, the inventory required now becomes approximately 66,000 units. This represents 88 weeks worth of demand.

One, or all, of the items considered has exaggerated the requirements. Figure 3-5 shows the top 79 SKUs in the whole batch of 257. It illustrates the cumulative percent makeup of the total demand that each SKU represent in descending order from most popular to the least popular. From this, it can be seen that the assumption that each SKU added will be divided by the total demand uniformly is invalid. It is quite clear that more than 200 SKUs are rarely demanded.

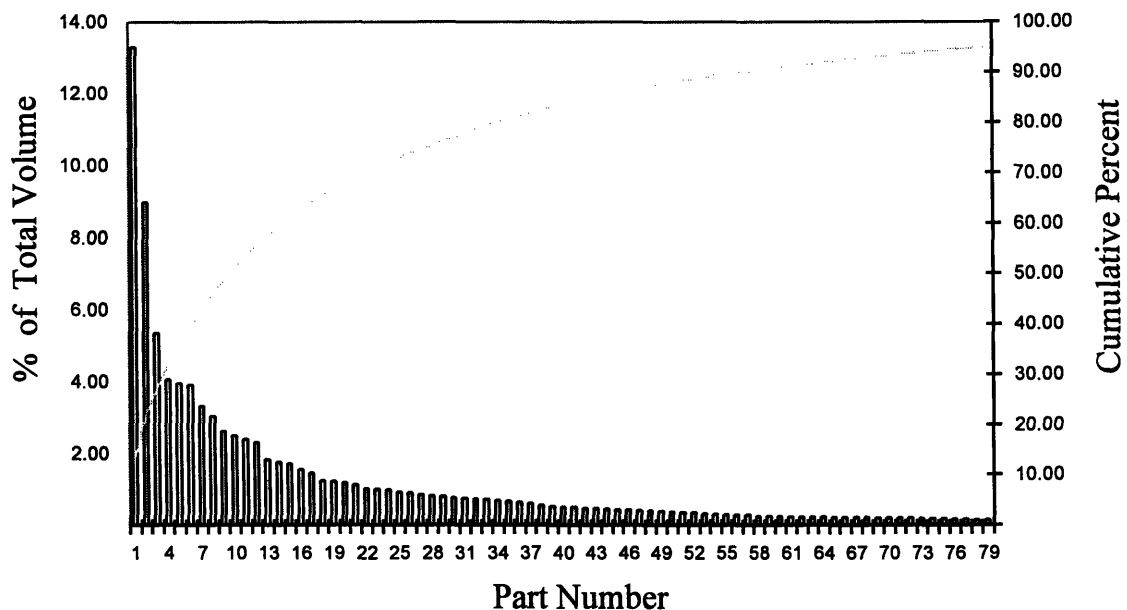


Figure 3-5: Pareto Diagram: 34 out of 257 SKUs Represents 80% of Actual Sales

Figure 3-6 provides an illustration that further invalidates the assumption. In this figure, the actual demand of the top ten SKUs are plotted. From this display, it can readily be seen that the variability in demand for each SKU is high, and does not appear normal. From section 2.4.3.1, that points out that inventory is used to buffer against variability, it is known that this would cause additional inventories to be stocked.

Given this realization, it is obvious that using the square root of 257 was mis-stating the impact, but to what extent is not clear. If a different number like 50 SKUs is used, the total inventory becomes almost 29,000 units. This is still 50% more than the actual inventory. However, since there are 50 stocking points, and 50 SKUs, the inventory in each stocking point will be approximately 580 total units with approximately 12 of each variant. This almost sounds like a reasonable amount to hold at each site. Herein lies the main problem.

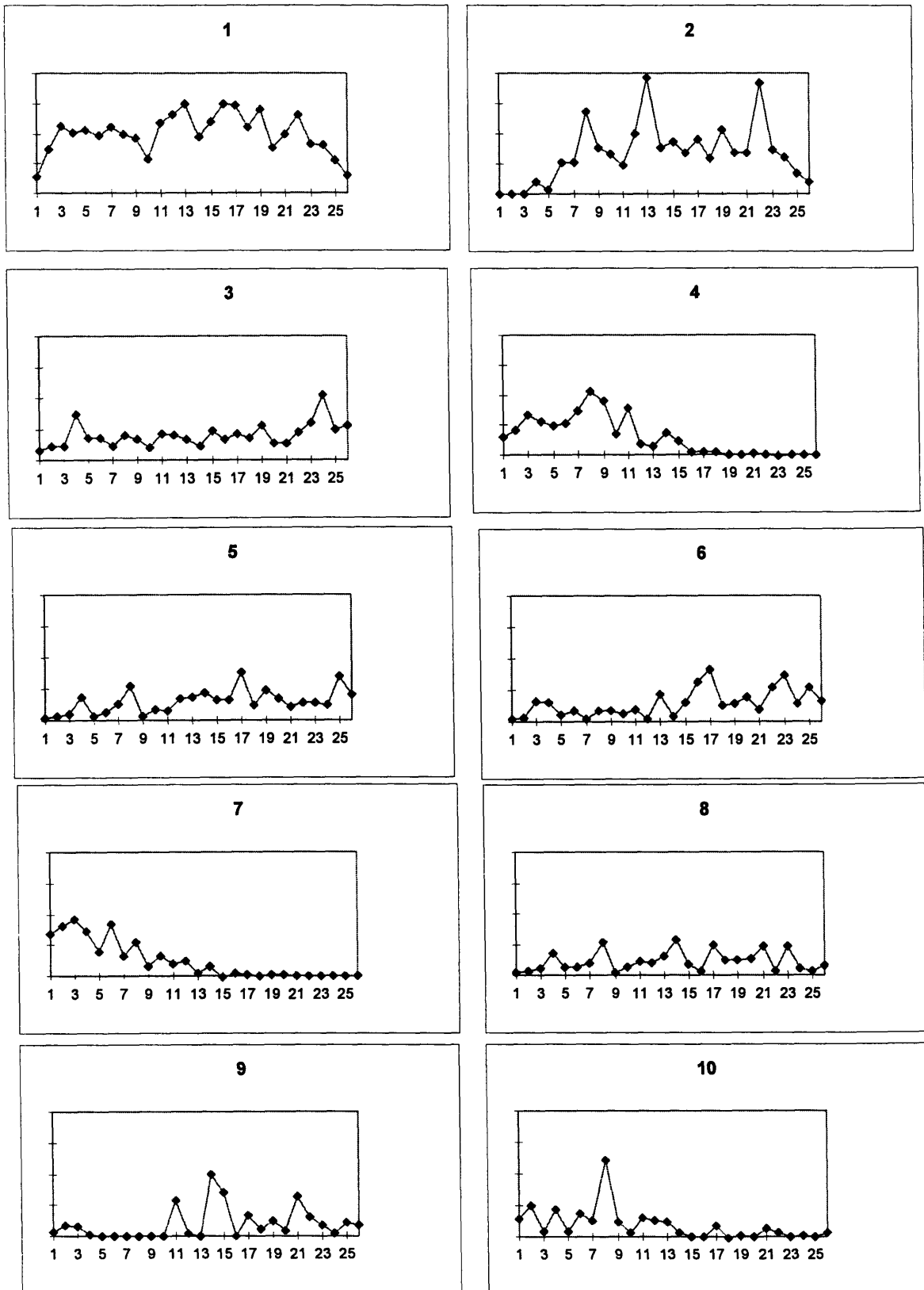


Figure 3-6: Demand Variability for Top Ten SKUs

By proliferating the SKUs in the factory, it becomes fairly easy to imagine the rationalization of the storage of 12 of each in each location. Likewise, however not as obvious, it seems logical to understand how 580 units would be appropriate to hold overall. After all, some distributors and resellers sell more than 500 units in one week.

It is primarily for SKU proliferation reasons that partnering is being advocated. A partnering concept to consider is the migration to a kernel or open-bay build concept.²⁷ In this concept, the manufacturer provides a limited number of basic units and some of the required extra materials to the value adding distributors. These distributors proliferate the SKUs as they are sold to end users.

With SKU postponement, the base kernels could conceivably be reduced to 4 (2 Chassis and 2 Main Logic Boards), and relatively easily to 16 (2 Chassis, 4 Main Logic Boards and 2 Disk Drives).²⁸ By using 16 as the SKU number verses the 50 mentioned previously, the savings is approximately 50% of the overall safety stock. Here the exact savings are not known since it is a function of individual SKU variances and other issues. When this action is combined with other partnering actions such as reduction in the number of distributors or something equivalent, significant reduction is possible.

3.2.2.4 Other Factors

The remaining terms in Equation 4 should be considered as well. The cycle stock and transit stock inventories will be considered of little impact since combined they represent 1.5 weeks of demand. The only thing that may be done to reduce these is to reduce the lead time, but since the average lead time in this geography is 1 week, the 1.5 weeks is not really something that can be improved upon.

The Obsolete, New Product, and Returns inventories could be the source of much of the inventory. Due to the rapid product life cycles described previously, and the storage of multiple SKUs, it can easily be seen how obsolescence could be a significant factor. By establishing a SKU proliferation at the distributors, these factors will also be reduced.

New Product inventory seems to be less of a factor. This is claimed since there are few major desktop system changes that would cause a surge in demand. However, the introduction of new products will tend to make the stocked systems become obsolete. There is an interaction here that is difficult to quantify.

A clearly big issue would be the Returns category. Due to the terms and conditions of the sales agreements, there can be returns of 5 to 12%.²⁹ It will be claimed at this point that the accumulated inventory calculation did not account for this activity. Therefore, the actual inventory could easily be more like 16,000 to 17,000 units. This represents 21 to

²⁷ Kernel is Digital's terminology for a base unit that essentially has no identity. This level of product will likely have no hard disk drive, limited base memory, limited software, and may not have a CPU.

²⁸ See chapter 2, SKU management section, for a more general appreciation of this.

²⁹ The actual number was not provided here to protect contract sensitivity.

22 weeks; a reduction of 2 to 3 weeks. This may not seem very significant, but as will be shown in section 3.2.3, the cost implications are.

Another element that could reduce the inventory would be the use of a trans-shipment policy that would enable the shuffling of inventory in the channel. The use of this process was not readily confirmed or denied. With the structure of the current distribution system, this activity is not facilitated.

3.2.2.5 Root Cause

The final element to consider is why any business would want to hold any inventory, never mind a rapidly depreciating one, for any longer than reasonable. This leads to the sales and marketing terms-and-conditions presented in section 2.2.2. The terms provide the distributor with the immediate incentive to hold at least one month's worth of inventory in the flooring terms alone.³⁰ When extended payment terms are included, the incentive could climb higher.

The terms-and-conditions may actually become extended as part of the discounting and end-of-quarter quota meeting initiatives. When additional discounting can no longer be provided since it can reduce the booked revenue, the payment terms, and other less tangible issues are often modified.³¹ The effect is to decrease overall profits, but this is not readily obvious due to the accounting systems used.

3.2.2.6 Speculation Versus Build-to-Order

If a build-to-order model based on an ability to fill a customer order with the lead time is used, it is even more difficult to justify the inventory in the channel. For the purpose of this paper, this concept will not be considered in detail. However, if there is an ability to meet a portion of demand with the lead time, it should be considered since it will help reduce the overall inventories. This could be a policy such as an ABC system where parts in the A category are stocked, parts in the B category are built-to-order and parts in the C category are not built. With a policy similar to this, care must be taken to ensure that the policies selected are appropriate for the given product variability and any related changes (Lee and Billington, 1992). Partnering would facilitate this consideration.

3.2.2.7 Summary

The overall summary of section 3.2.2 is that the inventory accumulation is the direct result of having:

- So many stocking locations and SKUs that the system safety stock is excessive but does not appear so.
- Very generous business terms-and-conditions that encourages stocking of inventory.

³⁰ As described previously, the flooring terms are where the manufacturer pays the carrying costs and interest for a period of time specified in the contract.

³¹ Digital management interview. One manager indicated that many such actions occur across the industry.

- Overly complex management accounting and incentive system that effectively masks the driving issues and associated inefficiencies.
- An adversarial relationship with channel-partners that precludes all parties from taking a total global-optimum view of demand fulfillment.

3.2.3 Gross Margin Benefits

To present the benefits of partnering in precise cost savings terms is complicated and may disclose confidential information. What is provided instead is a presentation of the general savings conceivable through inventory reduction. The savings in terms of overall gross margin will be approximated using discounted cash flow analysis and several simplification assumptions. The main factors considered are those of inventory depreciation and improved cash management. Appendix B should be used to gain an appreciation for the concepts used in this section.

To estimate the savings, the discounted cash flow analysis spreadsheet described in Appendix B was used. With this spreadsheet, the following question was answered: *“What is the percent savings of cost to the distributor that inventory reduction provides?”*. To put this another way; *“How much can gross margins be reduced while still maintaining the same net present value if channel inventories are reduced?”* To answer this, the spreadsheet was used to construct Table 3-3 for the case of a common net present value (NPV) with 7% monthly inventory depreciation and all other assumptions described in Appendix B. The relationship is plotted in Figure 3-7.

Gross Margin	Weeks of Inventory
2.09	0
3.94	1
5.79	2
7.64	3
.	.
.	.
.	.
46.58	24

Table 3-3: Gross Margin and Inventory Combinations for Same NPV³²

³² These numbers were calculated using the spreadsheet of Figure B-2 with an NPV=0.

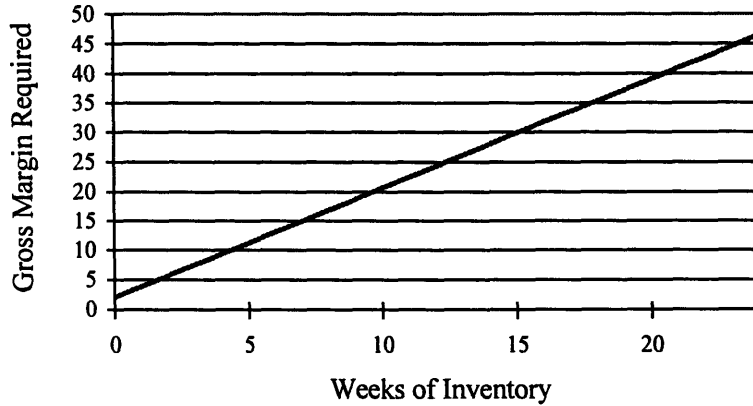


Figure 3-7: Gross Margin Required by Weeks of Inventory for Same NPV

From Figure 3-7, it can be interpreted that a reduction of a minimum gross margin required by 1.9% is feasible for every week of inventory eliminated.³³

While not conducted in detail, additional use can be made of the spread sheets like the one described in Appendix B. What if scenarios can be run to provide information like how inventory levels affect NPV for a given gross margin and depreciation rate (Figure 3-8). Additional information like how gross margins affect NPV for a given inventory level and depreciation rate (Figure 3-9). The potential combinations are too numerous to list. This concept is used in section 5.4 to establish some generic relationships.

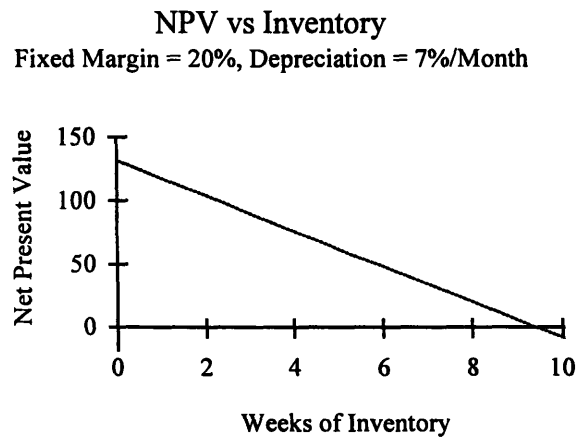


Figure 3-8: NPV vs Inventory for a Specific Inventory and Depreciation Level

³³ This chart indicates an approximately linear relationship. This relationship is linear by each NPV level within a reasonable range. As other levels of NPV are used, the slope changes gradually, but the relationship remains approximately linear.

NPV vs Margin
Fixed Inventory = 1 Week, Depreciation = 7%/Month

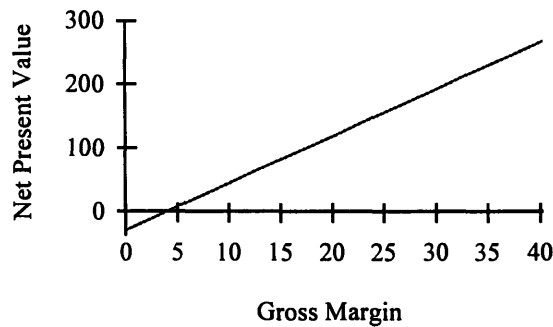


Figure 3-9: NPV vs Gross Margin for a Specific Inventory and Depreciation Level

3.3 General Observations

There are several observations that can be made from this analysis. In this section, three main themes are brought out to summarize the environment. These themes indicate that there are multiple factors acting against the manufacturer that should be addressed. Each one of these elements is expounded on in sections 3.3.1 through 3.3.4. These factors can be summarized here:

1. Suppliers Take Advantage
2. Distributors Take Advantage
3. Manufacturer is Own Worst Enemy
4. Accounting Systems are Ineffective

3.3.1 Suppliers Take Advantage

Materials vendors make large and predictable price cuts throughout the year. Since their products depreciate due to advancement in competitive technologies, these cuts must be made. Shortly after the end of a quarter is when many of the vendors make the cuts. They do this to take advantage of the forward-buying made by the distributors that effectively helped to clean out the suppliers' finished-goods inventory.

If material vendors know there is going to be a channel-stuffing related surge in demand at the end of the quarter, they will rationally wait until the stuffing is over to drop their prices. The manufacturer is now stuck with these depreciated inventories since the terms provided to the distributors protects them from exposure. Partnering will change this dynamic. This issue must be considered when an effective partnership is established.

3.3.2 Distributors Take Advantage

One of the immediate observations is related to the end-of-quarter skewed load on the production facility. From the factory demand picture, Figure 3-1, it can readily be seen that there is the hockey-stick affect. When the actual sales are observed, it is clear that this is artificial.

This is a reflection of the buying-patterns of the distributors. It is directly related to the terms-and-conditions presented in section 2.2.2. The distributors know that they are going to get these discounts so they take advantage of them.

3.3.3 Manufacturer Can Improve

The primary realization here is that every week of inventory requires significant margin. Whether it is 1 or 2 or even 3% per week exactly is not important. What is more important is the general realization that placing inventory in the channel in the hopes of forcing the sale can have significant negative cost related ramifications.

One of the major observations that should be made is the apparent building of twice what sells through to the end-user, as can be seen in Figure 3-2. This activity is an artifact of metrics that are not aligned properly. Incentive systems that do not adequately take into account the true costs of business can lead to this type of behavior.

SKU management is critical. Several times during the assignment that provided the basis for this paper, computer chassis were air-freighted across Continents due to a surge in demand. In reality, there was not a real surge in total demand, just one for a particular SKU. It turns out that there were plenty of chassis in the system, they were just part of other SKUs.

3.3.4 Accounting Systems Ineffective

The final observation relates to the difficulty to obtain actual cost information. The management systems observed were complex and not readily compatible across functions. This fact made it impossible to gain a complete understanding of the system. This issue itself could be a major drive of the inventory build up since an overly cumbersome management control system could increase transaction processing costs which will, in itself, provide the incentive for members to act in a locally optimizing manner.

4. Channel-Partnering

Chapter 3 provided an analysis that identified the benefits of inventory reduction for a manufacturer of commercial PC products. This chapter is intended to provide an intuitive appreciation for how channel-partnering can be used to reduce the inventories required.

Partnering is first described in section 4.1. Included in this section is an illustration of how partnering helps, and when it is generally appropriate to consider partnering. In section 4.2, several partnership types are illustrated for a general appreciation of their applicability. Section 4.3 provides some of the requirements for a successful partnership. In section 4.4, the results of chapter 3 are considered with the channel-partnering elements to convey how partnering can help. Section 4.5 addresses some specific challenges related to the implementation of a channel-partnering effort.

4.1 Description

Partnering, in a general sense, is the establishment of formally cooperative and collaborative relationships with other firms in the process of providing a product or service to an end-user customer. Partnerships can be as formal as a strategic alliance, or as informal as an implicit agreement to work together. The basic reason to consider partnering is to gain process technologies, market share, or organizational efficiency improvements through synergies that enhance the overall performance of each of the partnership members.

The intent in a strategic partnership or alliance is to reduce risk thereby lowering total costs and/or increase value for the channel, thereby achieving mutual benefit (Anderson and Narus, 1991). The ultimate goal is to maximize shareholder value while increasing the relative value of an integrated channel's product or services to the end-user.

4.1.1 Zero-Sum-Game

To articulate the value of partnering, the zero-sum-game analogy will be used. A zero-sum-game is a game where any winnings are gained through losses by other players in the game. This type of game can be thought of as an attempt to divide a fixed amount of money, with the winner being the one with the most. The traditional supplier-customer adversarial relationships essentially provide these results; someone wins and someone loses. Rarely do both parties leave truly satisfied with the arrangement (Shapiro and Heskett, 1985).

With this paper, a fully-integrated demand-fulfillment partnership is being advocated to change the game to a positive-sum-game. This is where the more the players work together, the more money there is to be divided. A new challenge here becomes determining who gets what portion of this increase. However, even if the relative percentages remain constant, it is in everyone's best interest to increase the magnitude of their share.

4.1.2 Product/Channel-Partner Matrix

A representation that provides a lens to consider situations where partnering is of value is to use a Product/Channel-Partner matrix.³⁴ This matrix is represented in Figure 4-1. Here, for simplicity, two types of products are represented relative to two distribution-channel members. The boxes are where the business relationships are defined. The numbers inside each of the boxes are the quadrant labels.

Product	Core	No Partner 2 Mfg'ers Terms	Full Partner 1 Pipeline Inventory
	Non Core	No Partner 3 In-Direct Dealing	Full Partner 4 Build To Order
		Less Important	Key/Strategic
Potential Channel Partners			

Figure 4-1: Product/Channel-Partner Matrix

In quadrant 1 of this matrix, the desirable business relationship would include the establishment of channel-partnerships or inter-company-operating-ties. Here the objective is to make the value-chain essentially a pipeline to the customer with minimal inventory. Each member of the value-chain will act as if they were part of the same company. This relationship would be optimal since there will be frequent transactions with these channel-partners therefore efficiency will save money for all members.

In quadrant 2, the business relationship should be reduced to one of providing a distributor with the products on the manufacturers' terms, or buying from a supplier only when there is a clearly supportive reason to source outside of the current partnerships. Here the objective would be to provide product, or procure parts, when it does not disrupt the relationship in quadrant 1. It would be important to maintain, or pay a higher price to these channel members since the prices in quadrant 1 are related to the overall efficient business relationship that led to them. If a marginal cost argument is used to rationalize equitable support of a quadrant 2 member, a conflict may arise that jeopardizes the

³⁴ This general framework was proposed by Dr. Jonathan Byrnes. It is presented here with the author's interpretation and customization.

relationships of quadrant 1.³⁵ This overall approach is optimum for each member since it would be a signal of a commitment to the other members.

In quadrant 3 of the matrix, the business relationship should essentially be non-existent. If it must exist for some reason, the best way to manage this may be to have the less important member source through the key channel-partner. If this method does not work, and it is important to deal within the area, a further modification to terms should be taken, perhaps in the form of even lower service levels and higher prices. This is considered optimum since any dealings in this area could undermine any relationships that have developed in quadrants 1 and 4.

The final situation to consider is quadrant 4. Since this is with the key channel-partner also, it is important to establish and maintain channel-partnerships, but they do not have to be as efficient as those in quadrant 1. Here a lead-time and/or inventory tradeoff might be a way to manage the associated variability. A good partnerships will enable the addressing of this issue when it arises, perhaps in the form of a custom build-to-order manufacturing control system.

4.2 Types of Partnerships

There are many types of partnerships that could be considered. In this section, five partnership types are described.³⁶ Each of these can be considered channel-partnerships since they involve independent members of the value-chain, or distribution channel. An example is provided for each type described.

1. Supplier-Manufacturer Partnerships
2. Manufacturer-Distributor Partnerships
3. Distributor-Retailer Partnerships
4. Product Development Partnerships
5. Fully-Integrated Supply-Chain Partnerships

4.2.1 Supplier-Manufacturer

The first partnership to be described is the supplier-manufacturer partnership. Perhaps due to the just-in-time (JIT) movement, this is the most widely discussed partnership type. In these partnerships, the manufacturer reduces the number of authorized suppliers to one or two from several. The supplier in turn agrees to take on more responsibility for the manufacturer. The relationship should improve transaction processing costs, quality management costs, and overall security of demand and supply for the partner members.

³⁵ A Sloan School colleague, Troy Ziegler, took the argument one step further to state that the value of a product delivered through a channel relationship is directly related to the relationship and that providing the product at the same cost without the relationship can jeopardize the prime relationships. The product is not actually the same without the integrated channel-partnership.

³⁶ These are by no means the only types of partnerships that are feasible. They are considered the most relevant to help the reduction in total PC business process costs.

The Bose corporation provides one of the best known examples of supplier-manufacturer partnerships. With JIT-II, Bose has supplier personnel working in the factory to manage their material supply and quality.³⁷ This provides a method for the supplier to be in tune with many opportunities for improvement that the traditional arms-length relationship between suppliers and manufacturers do not provide. Vendor-managed inventory programs of this nature help to reduce overall inventory levels, compress order cycles, reduce procurement related costs, and reduce stock-outs (Johnson, 1994).

4.2.2 Manufacturer-Distributor

The second partnership listed is the manufacturer-distributor partnership. An appropriate application for this partnership is in an industry that supports production-oriented value added after the manufacturing operation. In this type of application, since the distributor provides further transformation of the finished product, it is in the best position to support SKU proliferation through a postponement manufacturing strategy. An example of this would be the indirect-distributed commercial PC market. In a general sense it is the same as the supplier-manufacturer partnership with the manufacturer now being the supplier and the distributor being the manufacturer.

An example of a manufacturer-distributor partnership can be gained by looking at the General Electric (GE) Appliance Division and its Direct-Connect system. GE had a problem where its smaller distributors were not able to effectively compete with the big chains. The pricing schemes supported volume purchasing which led to inventories being in the wrong place and the loss of some accounts that just could not afford to compete.

GE established strategically located warehouses that stocked a much smaller portion of inventory than the original system, but increased overall availability through a virtual inventory system.. Any dealer in over 90% of the country would have access to the inventory via computer and simply pull from the inventory when needed and receive the product within 24 hours. The dealer would get the same price whether buying 1 or 100 units. Not only did GE's sales increase and its overall inventories reduce, distribution and marketing costs went down by 12%. In addition, GE was able to reduce its terms to the distributor and thereby receive payment much faster than with the original system (Treacy and Wieserma, 1993).

4.2.3 Distributor-Retailer

Distributor-retailer partnerships are another example of an appropriate way to partner. In these arrangements, the distributor is a stocking-point for the retailer. The retailer gains the benefits of procurement-scale economies and the distributor gains the benefits of being the sole source of supply to the retailer. The benefits here are in terms of operational efficiency for both members and consistency of demand or supply depending on perspective.

³⁷ JIT-II is a service mark of the Bose Corporation.

An example of a distributor-retailer partnership can be provided with Cotter and Company. Cotter is a distributor for small to medium retail hardware stores. The partnership is established as a co-op arrangement. In this arrangement, Cotter provides the small retailer with the purchase power and supply access that the superstores have. Cotter's concept is to help the smaller companies participate effectively in a business being dominated by large volume retailers (Stern and El-Ansary, 1992).

Although wholly owned, the Cadillac division of General Motors provides another excellent example of a distributor-retailer supply-chain management partnership. This example is very much like GE's virtual inventory system. Cadillac chose Orlando as the site for its Florida distribution hub. It was here that it located a minimal level of finished goods inventory that was linked to distributors via computer.

The program was capable of helping the average distributor to reduce his on-site inventory from 200 to 50 cars. The main objective of this arrangement was to reduce the amount of finished goods in the field, while increasing production efficiency by producing what was selling, not speculative inventories. The system has been particularly successful in that it enabled the dealer to decide what cars to build, as opposed to having the manufacturer decide. The 42 dealers of Florida were able to pool their inventory and reduce risk thereby helping reduce overall costs of the chain (Orlando Sentinel, 1994).

4.2.4 Product Development

Product development partnerships are another important case that will be highlighted. In these partnerships, the producer of a technology, or a development service, will collaborate with the customer who produces or packages and sells a product. The benefits for the technology supplier is a focused product that accommodates the needs of the end-user base while using its underlying skills and technologies. The benefits for the customer is provided in the form of access to advanced technologies which enables differentiation based on time to market and satisfaction of specific customer needs.

A good example of product development partnerships is provided with the Chrysler Corporation. Chrysler out-sources much of its product development and manufacturing activities to third parties. These third party suppliers provide Chrysler with design skills or production capacity that it does not have, or does not want to have directly. These relationships reportedly saved Chrysler \$500 million in the 1994 year alone (Buerger, 1994).

4.2.5 Integrated Supply-Chain

The final partnership type to be described is the fully integrated supply-chain partnership. This is a logical extension of any progress in the other partnerships. In this type of relationship, the entire value-chain is coordinated to ensure that the total business process is as efficient as possible. It is important not to confuse this concept with vertical integration. Each of the integrated value-chain members is a separate firm acting with common interests. The general intent of this type of arrangement is to migrate from a

highly-speculative, anticipatory-based supply-chain to a flexible, lower-risk response-based supply-chain. In this arrangement, the producers make what sells and reduce speculation (Kotler, 1994).

A prime benefit here is to eliminate locally optimized performance that sacrifices the overall system cost. In these relationships, the suppliers and all intermediaries of an integrated supply-chain will manage their production based on what is purchased by the ultimate end-user. Supply-chain members that fully collaborate before others in a market stand a far better chance to capture market share than groups that are not integrated.³⁸

A good example of an independent-company fully integrated supply-chain management partnership is provided with the Calyx and Corolla (C&C) Company. C&C is in the fresh flower business. C&C partnered with its growers and Federal Express to provide customers with ultra fresh flowers at a reasonable price. The C&C managers fully recognized the need to integrate the functions and as such considered their direct mail catalogue operation to essentially be one leg of a three legged stool. With the other legs being made by the growers, and its distribution provider. With this business model, in less than 5 years, C&C grew from nothing to a company posting profits greater than 5% on sales of \$10 million (Brokaw, 1993).

It is not readily known what progress is being made toward a fully integrated supply chain by other players in the PC industry. There has been little publication of any advances in this area. There are reports of IBM and Compaq embarking on open-bay configuration postponement, but there is not a lot of detail provided (Bliss, 1996). In this arrangement, the computer company makes a base level unit with limited installed options. The distributor would then configure the system to meet the exact order to accommodate the end-user. It is very similar to the kernel concept that Digital is experimenting with and is briefly described in section 2.3.2.

This configuration postponement is looked upon favorably by the distributors. However, there is still an “air of distrust” among the distributors and manufacturers that must be overcome before these partnerships can become effective in the PC industry (Balch, 1996).³⁹

4.3 Partnership Requirements

There are many basic requirements to consider before attempting to establish a channel-partnership. These requirements can be broken down into internal and external elements. Both of these areas require alignment of objectives and the establishment of a commitment to the concept. These issues will be addressed here in general.

³⁸ This comment is made based on the illustration of logistics information systems by Stern and El-Ansary, p. 161. It has been extended to apply to the subject of integrated supply chain management.

³⁹ Inacom, a US PC distributor indicated that IBM and Compaq were both going to be offering an “open-bay” environment in the first part of calendar year 1996. In the same article, there were many caveats presented about why this partnering will be challenging including this “air of distrust” comment.

4.3.1 Inter-Company Elements

To describe these elements, antecedent characteristics and expected consequences will be used (see Jap, 1995, for a detailed description and analysis related to these inter-company elements). The important antecedents can be summarized into two main characteristics; partner-firm, and interpersonal. The expected consequences can be summarized into the development of synergistic outcomes and idiosyncratic assets. In this section, some detail of these are provided.

4.3.1.1 Antecedents

The first of the antecedents to be described are the partner-firm characteristics. Jap describes these as goal-compatibility and complementary-competencies. Goal-compatibility refers to the extent to which each firm has goals that are similar which will eliminate the potential for pursuing an advantage that compromises the strength of the other member. Complementary-competencies refers to the degree to which each of the companies have resources that augment each others performance by filling in capability voids that one firm has and the other doesn't. Alignment of these characteristics alone can be enough impetus to drive a channel-partnering effort.

Jap shows that complementary-competencies are an important element to facilitate the development of strategic advantages together. These competencies ensure that the other member has the ability to expand market share. These competencies are particularly important to the buyers since they generally have more control than the suppliers over who to work with. At the same time, suppliers are more interested in goal-compatibility. Suppliers are more interested to know that they are moving in the same direction of their customer.

The final inter-company antecedents to be described surround the interpersonal characteristics. This element generally surrounds how the benefits of a partnership will be shared among the participants. Since the exact benefits of an inter-company relationship are impossible to anticipate, there will have to be a flexible success-sharing contract. This type of contract requires significant trust.

If past relationships between the potential partner-firms has been adversarial, and has caused distrust and suspicion, the firms will have more obstacles impeding working together. Jap shows that relationship can be successful despite past distrust. The key to success appears to be to have goal-compatibility and the which will enable members to work together and not act opportunistically.

4.3.1.2 Consequences

Expected consequences are important to consider when establishing partnerships. Three main outcomes could be expected through partnering; strategic advantages, higher joint profits, and idiosyncratic assets. Strategic advantages put the partnerships' products or services in a competitive advantage relative to other competing firms. Higher joint profits refers to the growth of profit for all members of a relationship as opposed to just considering one member. Idiosyncratic assets refers to assets, skills, or capabilities that

are not easily transferable across relationships. Thus, they lose their value if the relationship is terminated.

Jap shows that the establishment of interdependency does in fact increase strategic advantage, and joint profits. The interdependency also increases the development of idiosyncratic assets that provide the competitive advantage that is difficult for others to overcome. Since these relationships take time, and significant effort, they can become a source of sustainable advantage.

4.3.2 Intra-Company Elements

Establishing cross-company relationships has been argued to be perhaps the easiest of the barriers to overcome. Internal resistance issues often provide greater barriers to successful partnering. In this section, two of the intra-company elements are described; turf encroachment and operational change (see Byrnes and Shapiro, 1991, for more description of these elements).

4.3.2.1 Turf Encroachment

Issues of encroachment can surface in the purchasing and sales organizations as they can see these inter-organizational partnerships as an encroachment on their traditional responsibilities. These views are reinforced by narrowly defined compensation systems and poor communication of how partnerships can help remove the mundane elements of these roles and thereby elevate the significance of these roles.

4.3.2.2 Operational Change

Operational change is another major barrier to partnering. The establishment of collaborative inter-company operating relationships often leads to the elimination of some requirements or a change in long standing procedures or operating norms. Since it is in the overall best interest of the operation to make this change, this barrier will have to be broken down. Senior management participation in the process is often required.

4.4 How Partnering Can Help

Chapter 3 provided a detailed, intuitive gross margin savings argument to show the value of inventory reduction to the manufacturer. Included in section 3.2.2 was some of the drivers of channel inventories. The previous sections of this chapter provide the elements of channel-partnering. In this section the concepts of channel-partnering are applied to show how they can be used to reduce system inventories. Section 4.5 provides detail related to implementation challenges.

Since there are clear inefficiencies, and essentially all the value chain members are affected, partnering should be able to help reduce the total system inventory related costs in many ways. Since co-operation will lead to the member companies to obtain lower costs than when they performed individually, the arrangement is efficient and should work (Jarillo and Stevenson, 1991). This is the essentially the goal-compatibility element presented in section 4.3.1.

Table 4-1 lists some of the actions that partnerships will facilitate and how they could help reduce the inventory related costs. Each of these will help lead to the reduction of inventories and the related days of sales outstanding. Refer to section 2.4.3.2 and Appendix C to understand where these elements came from.

Partnering Actions to Reduce Required Margin With Better Asset Management	How This Could Help
Reduce service level targets; increase periods allowed to fill order where applicable	Reduce total system safety-stocks by serving a more manageable portion of the market and build some product to order.
SKU postponement	Reduce overall levels of safety stock and reduce related obsolescence
Stocking point reduction (this could be reduction in warehouses or even the number of distributors used)	Reduce safety stocks and hedging stocks and simplify control of system
Partner brokering or disposition of returns	Reduce returns of functional product
Product development collaborations	Develop products that are more suited for customer applications
Life-Cycle management	Reduce levels of obsolescence and related inventory mark downs
Simplify Management Control	Remove inefficiency of transactions; thereby reducing the tendency to bulk purchase.

Table 4-1: Actions that Partnering Facilitates and How They Could Decrease Margin Requirements

4.5 Implementation Challenges

From the previous sections of this chapter, it appears that the commercial PC market is a very good candidate for channel-partnering. However, there are many unanswered questions, and work that has to be done first. Issues of implementation related to specific challenges that were brought up in conversation or identified as barriers to success by Digital management are generally addressed in this section. It was beyond the scope of this paper to work out all the conceivable implementation issues in detail.

4.5.1 Lose Market Share

The argument here is related to the current practice of channel-stuffing by many of the manufacturers. The concept is that the person who stops stuffing the channel will lose market share to those members that continue to stuff the channel. The argument is based on the idea that the distributor has a limited amount of cash to buy PCs with. If the vendor currently allocates 10% to a manufacturers product and that manufacturer decides to partner and only provide a minimum level of inventory, the vendor now has cash available to spend on the competitors' products.

While the concept can be generally supported as intuitive, since the distributor does gain some increased stock out risk exposure, it would clearly be an inefficient move. Provided no other business practices have changed, due to the inventory-related costs, this action would be a sub-optimal business decision. True partnering will ensure that this inefficiency is identified and avoided since it is a common goal for each member.

With partnering, the channel member will know that it is not in his best interest to continue this inefficient behavior. The manufacturer will have worked with him to establish an understanding of the profit opportunities related to ceasing this practice. The distributor should, in-fact, be more tempted to reduce the levels of inventory it hold of the competitors' products. As an insurance, a manufacturer could contract with the vendor to ensure that he continues to maintain a certain level of business, but this should not be required provided the goal-compatibility is completely understood.

4.5.2 Metrics and Organizational Change

The performance metrics and compensation formulas for many people could easily be a stumbling block in the implementation of a partnering program. Without changing them, management remains influenced to continue the old practices. The current practices tend to focus on groups, product lines, companies, and other segregation that can inhibit overall cooperation.

Companies considering the implementation of an integrated supply-chain often must re-design the organization and establish new incentive systems. There are instances where partnerships have translated into low overhead, lean staff, and few middle managers (Johnston and Lawrence, 1988). It is beyond the scope of this paper to address them in full detail, however they should be considered in a diligent partnering effort.

To make this change, management should consider the underlying objective of current methods. The objective is usually intended to increase shareholder wealth through the reinforcement of specific behaviors. The problem is that the metrics often encourage behaviors that do not readily support this objective. Which specific metric changes and related compensation formula modifications should be made depends on the structure of the system being used.

New metrics should be established to consider inventory measures across the total supply-chain and total response time instead of an individual sites' lead time. All entities should be responsible and held accountable for the performance of the entire system (Lee and Billington, 1992).

4.5.3 Who to Partner With

This subject is a major concern that must be addressed. As was highlighted in Chapter 3, some of the requirements for a successful partnership include goal-compatibility and complementary-competencies. While it may be possible to consider partnering with all distributors, it is more likely that by limiting the number, goal-compatibility is enhanced. This compatibility should be enhanced since it is clearly a goal of a distributor to lessen the capabilities of his competitors. If a manufacturer decides to attempt to work with all distributors, there is an implicit disregard for this key goal of an individual distributor. Jarillo and Stevenson claim that this focusing of relationships can provide the individual attention that will eventually develop trust and build a truly effective relationship.

For the indirect-distributed commercial PC market, the number of distributors selected should be reduced to provide safety stock reduction benefits while maintaining sufficient presence in all the areas of demand. Since resellers readily procure PCs from any of the major distributors, limiting the number of distributors should provide the benefit of having adequate stocks for large orders at one location as opposed to having the product spread out in smaller volumes.⁴⁰

The distributor selected should be based on reputation and the perceived ability to develop long term trust and genuine co-operation. An assessment of the core values of the distributor and how he is received by resellers should be completed. This process will have to be conducted carefully to ensure that the ultimate efforts taken to partner are focused efficiently. Along with this assessment, any complementary-competencies should be identified since they will also assist in relationship development.

A concern that must be managed with this limiting of partners is related to other business units that may use the same distribution channels. If a manufacturer decides to limit his dealings to a select few distributors, he must understand the potential impact on any other business unit's product sales. This could be a two-way issue; by selecting and focusing, improved sales of the company's other business unit products could be gained.

4.5.4 Supplier Lead Times

Due to the long lead-times and relative power of the suppliers in the channel, this has been presented as a potential barrier. It has been proposed that pulling inventories in from the distributors will leave the manufacturer holding the inventory in his factory. This will have the effect of making the inventory a clear liability when quarterly results are presented. An analogy that clearly presents this concept is the idea of pushing down on a water bed. A person can push down on an area, but other areas of the bed will rise.

Partnering will facilitate the addressing of this issue. There are two things that can be done. The first is to buy from suppliers that are interested in establishing an integrated supply chain due to goal-compatibility. The other thing that can be done is to work out an arrangement where the supplier takes on more responsibility for the inventory through a deal where the manufacturer actually pays more on a per part basis.

4.5.5 Initial Adjustment

Another implementation barrier that has been raised is how to migrate to a minimal safety stock level without significantly reducing the load on your production facility and basically stopping new sales until the channel inventory is brought down to the target level. The most significant issue here is the potential adverse reaction of the capital markets.

⁴⁰ Digital management interview: Resellers often use speed-dialing phone systems that enable them to rapidly meet a PC order by buying from one of many distributors.

This situation will have to be managed carefully. Since it is truly in the interest of the shareholders to establish these efficient partnerships, it should not be a real concern. Communication of the initiative and its value should help stem this concern. If this issue is looked at in total, it becomes irrelevant. One way to present the action is to articulate that it is a sunk cost issue, the problem has already occurred and this action is being taken to make the situation better.

This may or may not be a real issue. If the initiative is going to provide value to shareholders, the markets should recognize and reward this behavior. For example, Apple Computer recently took a \$700 million hit on its books and the stock market reacted with a six percent jump in value. The markets reacted positively since Apple was getting the bad news out quickly in order to focus on re-building the company (Associated Press, 1996).

At a minimum, if this is considered a major concern, a gradual phase-in of the program could be completed over several quarters. In the meantime, all practices related to channel stuffing and related inefficient actions should be stopped to help reduce total inventories. The total system and related inventory exposures should be carefully considered to make this transition smooth.

4.5.6 Information Sharing

To be effective, information technology and data management will be critical requirements for channel-partnering implementation. The data sharing mechanisms and related infrastructure should be established to facilitate communication. Data to be shared include such elements as forecasts, finished-goods inventory levels everywhere in the chain, backlogs, production plans, supplier delivery schedules and overall pipeline inventory. An employee at any point in the supply chain should be able to retrieve accurate and useful information quickly (Lee and Billington, 1992).

With this element are concepts such as automated processing of order fulfillment transactions. Here, concepts to consider include: bar code scanning, electronic data interchange and electronic funds transfer. These are considered key-elements of partnering and necessary-changes for companies who have successfully partnered (Jap, 1992).

Along with this information sharing element is the issue of information protection or security. Companies involved in partnerships that are based on goal-compatibility will be driven to establish protective procedures to ensure their competitive advantage. This will have the effect of reducing this issue.

5. Conclusion

In this chapter, the general conclusions of the thesis are drawn and articulated. Goal accomplishment, major conclusions, and recommendations are provided in section 5.1 and section 5.2 respectively. Section 5.3 lists specific recommendations for Digital. Section 5.4 provides some comments on the general applicability and management implications of this work. Section 5.5 details some of the issues that should be worked on further to implement a successful channel-partnering effort. A final summary is provided in section 5.6.

5.1 Goal Accomplishment

When a manufacturer produces products that depreciate rapidly and have commodity-like market appeal, this paper clearly indicates that it is valuable to consider partnering for the improvement of asset management. This work indicates that each week of PC finished goods inventory eliminated can have the effect of saving approximately 1.9% margin for the channel members.⁴¹

When the additional savings related to improving the economics of order fulfillment related transactions, and other assets not identified are included, channel-partnering becomes even more attractive. Since Digital's distributors, in the geography analyzed, currently carry excess finished goods inventories, this concept should be considered.

5.2 Major Conclusion

The overall conclusion is that the indirect distributed commercial desktop PC market is a good candidate for asset management improvement through channel-partnering. There are several reasons for this and they can be summarized here:

- There are inefficiencies in the current business model for each member of the value chain.
- The rapid depreciation of inventories makes holding them undesirable.
- High inventories are not required with effective channel-partnering.
- Significant cost savings, thus higher margins, are possible through a reduction of inventories.
- Higher margins for members of the partnership will increase sales and profits.
- The first manufacturer to do this will gain a competitive advantage and thereby increase market share.

⁴¹ See chapter 3 for the origin of this 1.9% number.

5.3 Recommendations

This work provides the support for the assertion that partnering can be of true value to an organization that produces and distributes products that devalue rapidly. The efforts to find supporting information and to understand the system highlights another area for improvement; simplification. When all of this is reflected upon, the following actions are recommended:

1. Establish focused partnerships to reduce inventories and subsequently increase margins, market share and profits. These partnerships should do the following:
 - Reduce inventories while maintaining desired service levels
 - Postpone SKU proliferation
 - Reduce system stocking points
 - Increase market share and profitability through higher margins.
2. Simplify the order fulfillment system and related management control systems to openly coordinate performance while maximizing value.

5.4 Generic Applicability

This work accentuates the value of taking a total business process perspective when designing and managing order fulfillment systems. The approach employed in this paper should apply to other industries that are considering supply chain partnering for business process improvement. Overall, in situations where inventory-depreciation is high and margins are low, the establishment of partnerships should be a common goal.

Figure 5-1 and Figure 5-2 show the relationships between NPV and inventory in various gross margin and inventory depreciation environments. These figures can be used by the general manager to establish new, or assess existing competitive strategies.

Margin and Inventory-Depreciation Relationship

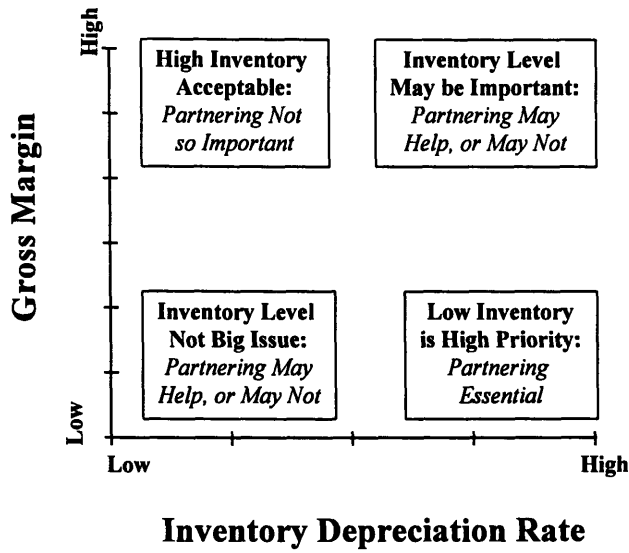


Figure 5-1: Depiction of how Gross Margin and Inventory Depreciation Rate Relate to the Desired Level of Inventory and Hence the Partnering Value

By working with Figure 5-1, the owner of a one-cent candy-shop (low-to-no depreciation and very-high margins) can show that the consultants' recommendation to partner with their suppliers to reduce inventory is not desirable. Likewise, a business person in the fresh-seafood industry (very-high depreciation) can intuitively argue that partnering is of significant value if the target customer is a low-margin supermarket chain, but that it may not be as important in the high-margin, specialty stores.

Net Present Value and Gross Margin Relationship
Shows ISO Inventory Lines for One Inventory Depreciation Rate

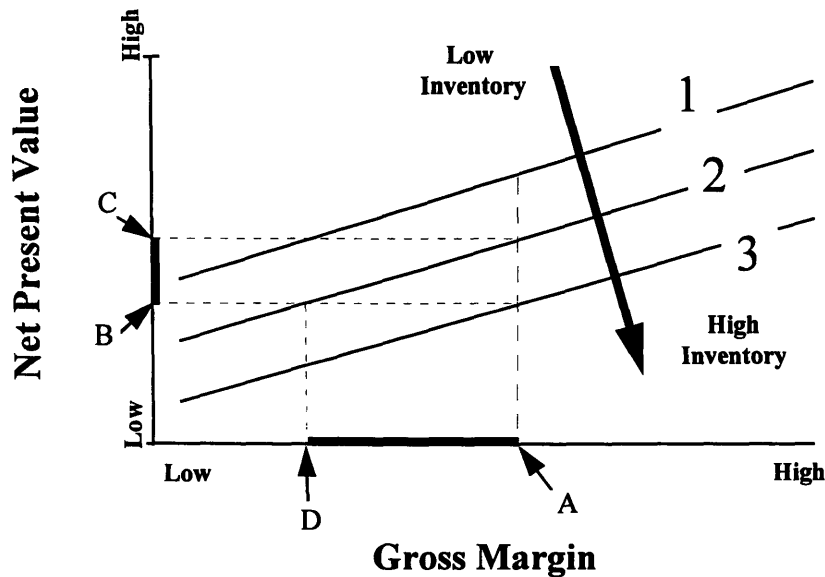


Figure 5-2: Depiction of how a Modification of Inventory Level Improves NPV

Figure 5-2, can be used to present someone with a detailed understanding of the benefits of partnering. This figure could be augmented using the spreadsheet of Appendix B, and the industry specific information, to show clearly the specific effects of decreasing inventory. With this figure, it can clearly be illustrated that by changing inventory levels from 3 to 2, will enable the gross margin to be decreased by (A-D) for the same value to the business. Likewise, if the gross margin is acceptable at level A, the value to the business can increase by (C-B) by making the same inventory change.

In general, these figures provide an intuitive framework for when it is appropriate to establish integrated order fulfillment systems. Concepts such as partnering, which works to reduce inventory exposure, can be generally assessed using these figures to show how the inventory positions affect the system. With the inclusion of actual numbers from the business, these figures could be used to clearly articulate the bottom-line benefits of an initiative.

5.5 Areas for Future Work

There are clearly several things that must be done before Digital, or any other company for that matter, can put the information conveyed in this paper to work. This section provides a general listing of actions that Digital should take for an effective channel-partnering initiative. Each one of these elements is expounded on in sections 5.5.1 through 5.5.6.

1. Assess Partner Potential
2. Conduct Kernel Level Analysis
3. Determine Control Requirements
4. Establish Education Program
5. Implement Partnerships
6. Extend Analysis

5.5.1 Assess Partner Potential

Determine supplier and distributor needs explicitly and determine where goals are compatible and competencies are complementary. As described in section 4.3, there are factors that must exist for a successful partnership. Along with this element, a partner assessment and relationship management process should be established.

5.5.2 Conduct Kernel Level Analysis

Identify what kernel level is appropriate for SKU reduction and work on details related to how components would be managed. Specific analysis should be conducted to identify and establish actual safety stocks for each level of inventory. This will be a complicated process that takes into account historical sales, and channel-partnership goals.

5.5.3 Determine Control Requirements

Identify organizational and management control requirements. With this comes the mandate to determine appropriate metrics and compensation plans to modify and positively influence behavior toward the ultimate goals of the partnerships.

5.5.4 Establish Education Program

Establish ways to sell partnering with parties that do not readily see the overall value of participating or relinquishing power. Both inter-company and intra-company elements must be addressed.

5.5.5 Implement Partnerships

The overall objective is to make more money through effective channel-partnering. For this reason, it is important that the implementation be completed. This could be done through a focused demonstration of the value. Once a small scale partnership is demonstrated as successful, a full scale partnering initiative can be more easily supported.

5.5.6 Extend Analysis

This analysis was based solely on the commercial PC market for one specific geography. More work should be conducted to understand the applicability of partnering toward the remaining market segments. Digital should apply partnering concepts to all remaining market segments not addressed in this paper (i.e., servers, mobiles, geography, etc...).

5.6 Summary

A commercial PC rapidly depreciates and is has limited specific brand appeal to the end-user. These features imply that the competition basis of the major players will be primarily cost, with a given level of quality and delivery. The key to success in this environment is to have low-to-no inventory exposure.

Aside from migrating to a direct, build-to-order business model, an apparent solution is to partner with other members of the value chain to reduce the total system costs. Channel-partnering will help to reduce overall inventory through focusing this management priority as a common goal for the value-chain members. This arrangement will lead to a better cost position which should lead to improved margins for all stakeholders. The improved margins and conceivably lower end-user price should increase market share and profits for the integrated partnership.

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APPENDIX A: COMPETITIVE ANALYSIS

This appendix describes the competitive nature of the commercial desktop PC market. Provided is an analysis based on Michael Porter's Five-Forces Framework.⁴² A summarization indicates that the indirect distributed commercial desktop PC market is *not attractive* to participate in.

Five Forces Analysis:

With this analysis, the forces exerting pressure on a manufacturer or other such organization are considered. The intent is to understand the general competitive attractiveness of the industry relative to the specific market segment. If all forces are low, then the competitive attractiveness is very positive and any firm that is participating should be extracting high profits. If all the forces are high, the industry is going to be very difficult to participate in and the participating firms will extract low or no profits. Combinations of high and low forces will have various implications.

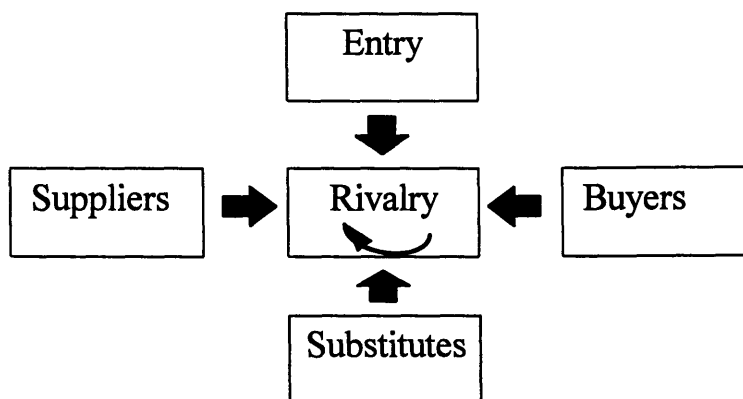


Figure A-1: Depiction of the Five-Forces acting on the Manufacturer

Figure A-1 depicts the Five-Forces acting upon the firm being analyzed. The firm should be thought of as being located in the middle box with each of the forces acting upon it. The Five-Forces are: Suppliers, Entry, Rivalry, Substitutes, and Buyers.⁴³ These forces will be described, with their level of pressure on the commercial desktop PC market participant.

⁴² Porter, Michael E., pp 3-33.

⁴³ Other categories related to Government and the Environment may apply, but are not required for here to support the illustration.

Suppliers:

This force represents the power the suppliers have in the relationship. If the supplier is the only provider of a product or service, and that service is required, then this power will be high. Suppliers here include those for hardware, labor, and distribution services to name a few. Table A1 provides a depiction of some of the suppliers and their relative power. Since the manufacturers of commercial desktop PCs have few alternatives for many components, overall this force can be considered high.

Supplier of:	Power
CPU	Very High
Operating Systems	Very High
Hard Disk Drives	Moderate to High
Chassis	Low
Monitors	Moderate to High
Miscellaneous	Low
Main Logic Board	Moderate to Low
Memory	Moderate to High
Labor	Low

Table A-1: The Commercial PC Manufacturer Suppliers have High power

Entry:

This force represents the ease with which competitors can enter the business. If the barriers to entry are low, then this force will be high. Entry requirements include issues related to design knowledge, cash requirements, proprietary technology access, and market access to name a few. Table A2 provides a depiction of some of the entry requirements and their relative impediment to entry. Overall this force can be considered high on the manufacturer.

Entry Element:	Relative Impediment
Design Knowledge	Low
Cash Requirements	Low
Technology Access	Low
Market Access	Low to Moderate
Brand Impact	Low to Moderate
Component Access	Low
Scale Economies	Moderate

Table A-2: The Commercial PC Market is relatively easy to enter

Rivalry:

This force represents the intensity of the rivalry of the current participants. If current competitive actions include active price wars and related promotional activities, then this force should be considered high. If the competitive actions are more related to peaceful

coexistence, then this force should be considered moderate. If there are no or very few competitors, this force is considered low. Given the number of competitors all vying for the same market, this force can be considered high on the Commercial PC manufacturer.

Substitutes:

This force represents the availability of substitutes for the product or service that the participant is providing. If there are many potential substitutes, then this force is high. If there is little or now choice, then this force is low. Substitutes would be items that serve essentially the same purpose, but are not the same. An aluminum can would have substitutes of metal cans, glass jars, and even plastic bags in various applications. The commercial PC has the potential substitutes of the mainframe computer system and perhaps other related items. Another brand of commercial PC would not be considered a substitute in this analysis. Given the evolution of the PC and its ubiquitous application, it is difficult to consider this force as being other than low overall.

Buyers:

This force represents the power the buyers have in the relationship. If the buyer is the only user of a product or service, and there is industry competition, then this force will be high. If there are few suppliers and one buyer, then the force will be high. If there are multiple buyers and one supplier then this force will be low. If there are multiple buyers and multiple suppliers then this force will be high.⁴⁴

To further complicate this element, it is important to define who the buyer is. For the indirect distributed commercial PC, the buyer in the strictest sense is the channel member.⁴⁵ Since mentioned reports have shown that this buyer is not very reliant upon a specific PC manufacturer, this power would be considered high on the manufacturer.

⁴⁴ The needs of the provider will also play a significant role. If the supplier must bring in a certain revenue to make money overall, they will be motivated to work with the buyer more and vice-versa.

⁴⁵ For the directly distributed commercial PC, the buyer is the end-user and the buyer power is high also due to competition.

APPENDIX B: FINANCIAL ANALYSIS

This appendix is provided to support Chapter 0 predominantly. It can be used to establish an appreciation for some of the financial management challenges present when managing in the indirect-channel distributed commercial desktop PC market. This appendix is not intended to provide the novice reader with a complete understanding of financial management. See (Brealey and Myers, 1991) for a more complete understanding of this subject.

Presented here is an illustration of the cash-to-cash concept, as well as a presentation on evaluation of the PC market challenges with a discounted cash flow analysis. The differences between a system managed as a partnership and as a non-partnership are generally presented.

Cash-To-Cash Cycle:

The first thing that is valuable to understand is the general management of cash in a business that is very capital intensive. Brealey and Myers emphasize that cash is as important as a raw material for business as any other. Without cash, or related credit, a firm cannot obtain the raw materials required for product manufacturing and related business activities. When manufacturing products with a high percentage of material content, the issue of cash management is significant.

The illustration that will be provided here is that of the cash-to-cash cycle. This is the duration from when the company pays its material suppliers to when it receives the revenue for the product that the materials went into. Since each member of the value chain has similar cash management issues, it is important to understand how the whole system works. Figure B-1 provides an illustration of the management cycle.

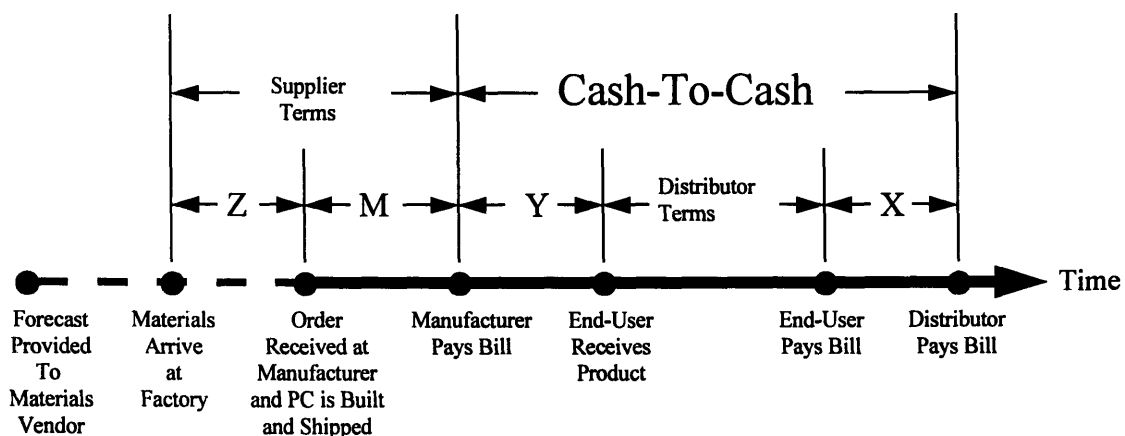


Figure B-1: Cash-To-Cash Cycle Illustration

In general, it can be seen from the figure that with the current terms-and-conditions, the manufacturer is dependent upon the end-user payment to receive payment. It can also generally be seen that the manufacturer must pay its suppliers according to the suppliers terms. This supports the argument that this is not the most attractive industry to be in since the manufacturer must pay bills quickly yet wait for customer payments patiently.

The period labeled as “Distributor Terms” refers the terms-and-conditions that the distributor extends to the end-user. These terms may be cash on delivery, or a thirty day payment after receipt of goods.

The term X in the illustration depicts the lag time between when the distributor receives payment and provides it to the manufacturer. In a solid partnership arrangement, this lag time could essentially be eliminated. Also significantly reduced through a partnership could be the amount of time that the manufacturer has materials that it has not placed in a PC, represented with a Z in the illustration. The concept of line-side-stocking, bill-on-consumption, or consumption-based-replenishment mentioned in section 2.4.1.4 could be used for this purpose.

Another initiative towards cash-to-cash reduction could be the reduction or elimination of the combination (Y+M) in the illustration. This combination represents the amount of time that it takes for the distributor to actually sell the product through to the end-user. Since the distributors often add value to the units, and since there is safety-stock, this term will not be zero, but it will be reduced significantly with partnering.⁴⁶

The overall cash-to-cash cycle can be squeezed through coordination of efforts which will help synchronize all the payment cycles. The ideal situation would be where all the value chain members have overlapping terms that enabled the supplier to be paid directly from the money received from the end-user within an acceptable time frame.

In the following section, the cash-to-cash issue, and related financial management implications will be made clearer.

Discounted Cash Flow Analysis:

To illustrate the benefits of partnering versus non-partnering in quantitative terms, the concept of discounted cash flow analysis is used. Present value (PV) represents the current value of expected future payoffs or receipts. The expected future benefits and costs are discounted to the present time to determine their respective present values. The overall net present value (NPV) of an initiative accounts for the PV of all disbursements and receipts.⁴⁷

The first thing that must be done is to identify the present value of all cash flows related to the initiative being analyzed. Each of these cash flows will then be discounted to

⁴⁶ These assertions of reduction are based on improving the whole process through partnering that will enable essentially consignment inventory managed safety stocks and a pull production system. The benefits are perceived to be substantial relative to the current channel stuffing practice by all value chain members.

⁴⁷ For a detailed explanation of these and related elements, see Brealey and Myers, pp 11-13, and 29-33.

time= 0. Table B1 provides a list of the cash flows that will be considered for this analysis. This list has been simplified for illustration purposes. A more detailed analysis could be completed as desired.

Cash Flow Element	Description
Materials Payment	Pay off Accounts Payable
Other Generic Pay	Pay Employees, and Other Generic Requirements
Safety Stock Inventory	Investment In Inventory and Relevant Opportunity Costs
Depreciation of Accounts Receivable	Account for Price Protection affect on Revenue
Revenue Receipt	Receive Payment for Goods

Table B-1: Cash Flow Elements to be Discounted to Present Value

For the purposes of keeping this illustration simple, there will be four present values calculated. The four will correspond to the first four cash flow elements presented. The fifth element will be accounted for in a revenue receipt inclusion.

To continue with this analysis, additional terms must be presented. The first of which is days-of-sales-outstanding (DSO). This is the M term in Figure B-1 combined with the cash-to-cash cycle time. On the average, it is the accounts receivable divided by the revenue per day.

Another term to be presented is the product cost. For the purpose of this paper, product cost is the cost of goods with all other relevant costs that are used as a basis for margin markups. This will include all materials costs, as well as additional direct and indirect elements.

Another term that is relevant is depreciation. This term is being used in a somewhat dissimilar context that most people are used to. Here the term is intended to represent the erosion of revenue expected as a result of price protection, discounting, and related obsolescence. Others use the term obsolescence to represent most of this. Depreciation is used here since it better indicates residual value while obsolescence suggests a terminal value of zero. Since there is a market for older PCs, this was determined to be an appropriate distinction.⁴⁸

Several simplifying assumptions are made to facilitate the analysis.

- The materials related costs will be assumed to be paid when terms indicate.
- All materials will be aggregated together into one payment time.
- The remaining cost elements will be assumed to be paid immediately upon construction of the units.

⁴⁸ This assumes effective life-cycle management. Essentially all PCs have a value that can be captured. The depreciated product will be more difficult to sell, and will not claim top dollar, but it is something that can be sold.

- Depreciation is assumed to be 7% per month in accordance with reports and observations made previously.
- All Revenues will be considered paid in the same week for all weekly sales made; partial payments will not be considered.⁴⁹
- Safety-Stock will be considered to have a cash outflow at time=0 and a recapture at the beginning of the next week. There will be a cost of carrying this related to the cost-of-capital and the depreciation over 1 week.
- An annual opportunity cost-of-capital of 15% is used.
- All calculations are based on 52 weeks per year, 7 days per week or 364 days per year. The depreciation and cost-of-capital rates are reduced to a weekly rate.
- Product cost is 75% materials and 25 % other and is constant for all periods.
- The number of DSO and the number of days it takes the distributor to sell are related. The distributor pays 30 days after they sell the product through.
- The amount of inventory in the channel is assumed to be owned by the manufacturer.

The general form of the PV calculation is provided in the following equation. Here, the discount factor is what is used to bring the value of a future cash flow to its current value. The term C_1 represents the future cash flow. The r represents the appropriate opportunity cost-of-capital.

$$PV = \text{Discount Factor} \times C_1 = \frac{1}{1+r} \times C_1$$

For the first category, Materials Payment, there is a variable element that must be considered. That element is the amount of time, from time=0, before the payment must be made. In Figure B-1, it can be represented by the M term. The appropriate cash flow to consider is the materials portion of the Product Costs. For this analysis, this is assumed to be $(.75 \times \text{Costs})$. The discount rate will be established using the following relationship:

$$\text{Discount Rate} = \frac{1}{(1+r)^n}, \text{ Where } r = \text{Cost of Capital} \ \& \ n = \text{Portion of year}$$

Using this relationship, the discount rate can readily be determined for different payment times. The n term is modified to represent the portion of the year that the days of payment correspond. For example, for a payment, or cash outlay in 12 days, the n factor is set to equal $[(12 \text{ days}) / (7 \text{ days per week}) / (52 \text{ weeks per year})] = .033$ years. By continuing with the discount rate equation, the associated discount rate would equal .9954. The PV of the material element would then be:

⁴⁹ The particular case of payment for only a fraction of what is sold into the channel is disregarded even though it is particularly appropriate considering the observations made in the results section that indicate a buildup of inventory in the channel. With this argument, the effect of not selling all is accounted for in the increase of the number of Days of Sales Outstanding.

$$PV = .9954 \times (.75 \times Cost) \times \frac{Volume}{Week}$$

The second element is the other generic pay term. The PV for this is straight-forward. Since the payment is being made in the current day, the PV is simply equal to the time=0 cash outlay. The term will be negative since it is a payment as opposed to a receipt of cash.

$$PV = -(.25 \times Cost) \times \frac{Volume}{Week}$$

The third element is the revenue receipt. This element is one where the depreciation of material value is accounted for. To make this calculation, the same equation used for the materials payment is used. The difference is that the DSO (divided by 364) is used for the n term and the cash receipt is the revenue depreciated over the time before the channel sells it. The depreciation against the revenue is calculated using the monthly depreciation rate (7%) over the (Y+M) time in Figure B-1. This (Y+M) factor is the actual amount of time the distributor essentially has the product, and thereby exposes the manufacturer to the risk of a price change in the underlying materials.⁵⁰ This equation is represented here:

$$PV = \frac{1}{(1+.15)^{(DSO/364)}} \times \left[REV \times \frac{1}{(1+.07)^{((Y+M)/7) \times (12/52)}} \right]$$

The final PV that must be considered is that related to the use of safety stock inventory. This element has two prime cash flow considerations; the investment and the residual value. The investment in the safety stock will simply be the negative outflow of cash at current time. The residual value will be a function of the cost-of-capital and the depreciation of the inventory. The following equation represents this PV Formula:

$$PV = \left[\frac{1}{(1+.15)^{(1/52)}} \times \frac{1}{(1+.07)^{(12/52)}} \right] \times (Cost) \times Weeks \text{ of Safety Stock} \times \frac{Volume}{Week}$$

All of the terms are added to construct the NPV value. There are three cash outflows (materials cost, other costs, and safety stock investment) and two cash inflows (revenues collected and safety stock residual value).

All of this information was incorporated into a spreadsheet to facilitate illustration. Figure B-2 is a representation of the spreadsheet that was constructed from the NPV relationship just described. From this, it can be seen that this investment, or business operation, has a positive net present value as illustrated.

⁵⁰ The price protection does not correspond directly to actual material price changes. It is the assertion of the author that the manufacturer who can better track the actual material price (or cost) changes with changes in their own product prices will gain a competitive advantage provided they have low to no inventory exposure.

	752	Weekly Unit Sales
\$	1.30	Unit Sales Price to Distributor
	30%	Gross Margin
\$	977.60	Weekly Sales Revenue
\$	1.00	Product COST
	75%	Materials Portion of COST
	25%	Remainder of COST
	0	Aggregate Average Days to Pay Materials After Production (Y Term)
	32	Aggregate Average Days Sales Outstanding
	2	Aggregate Average Days Required for Distributor to Sell (Y+M)
	15%	Annual Cost of Capital
	7%	Monthly Depreciation of Inventories
	0.3	Weeks worth of Sales - Safety Stock Committed
\$	(188.00)	Present Value of Cash Outflow Day 0
\$	(564.00)	Present Value of Cash Outflow When Materials Paid
\$	(225.60)	Present Value of Safety Stock Cost Outlay
\$	221.51	Present Value of Safety Stock on Week 2
\$	960.79	Present Value of Accounts Receivable Discounted Appropriately
\$	204.70	Net Present Value of This Combination

Figure B-2: Spreadsheet for Discounted Cash Flow Analysis - Co-operative Mode

Figure B-2 is actually representative of a situation where the operation is run in a co-operative mode with the distributors, and to some extent with the suppliers. This claim is supported by observing the DSO at 32, and the 0 days to pay the materials vendor to be conservative. Also claimed is a maximum of .3 weeks of sales worth of safety stock in the channel and a rapid sell through of 2 days for the distributor. All of this indicates that the spreadsheet of Figure B-2 is a close to an ideal situation.

	752	Weekly Unit Sales
\$	1.30	Unit Sales Price to Distributor
	30%	Gross Margin
\$	977.60	Weekly Sales Revenue
\$	1.00	Product COST
	75%	Materials Portion of COST
	25%	Remainder of COST
	0	Aggregate Average Days to Pay Materials After Production (Y Term)
	89	Aggregate Average Days Sales Outstanding
	59	Aggregate Average Days Required for Distributor to Sell (Y+M)
	15%	Annual Cost of Capital
	7%	Monthly Depreciation of Inventories
	8	Weeks worth of Sales - Safety Stock Committed
\$	(188.00)	Present Value of Cash Outflow Day 0
\$	(564.00)	Present Value of Cash Outflow When Materials Paid
\$	(6,016.00)	Present Value of Safety Stock Cost Outlay
\$	5,906.90	Present Value of Safety Stock on Week 2
\$	827.33	Present Value of Accounts Receivable Discounted Appropriately
\$	(33.77)	Net Present Value of This Combination

Figure B-3: Spreadsheet for Discounted Cash Flow Analysis - Current Mode

Figure B-3 is representative of a non-cooperative model. With this, the benefits of partnering become clearer. The first obvious difference is that the mode without partnering leads to a negative NPV. The numbers included were such that would aggravate the current business model to illustrate the inefficiencies. The elements that should be noted are the lower gross margins, the higher safety-stocks, and the extended terms on the accounts receivable.⁵¹

When a sensitivity analysis is conducted against the elements, using the co-operation model, the NPV relationships illustrated in Figure B-4, Figure B-5, and Figure B-6 can be established. For these relationships, the spreadsheet of Figure B-2 was used and the elements that were varied included: gross margin, weeks of safety stock and monthly depreciation rate respectively. When these elements were varied, all other terms were kept constant as shown in Figure B-2.

⁵¹ The numbers are not the actual numbers of Digital.. They are industry representative approximations that have been used to illustrate the argument.

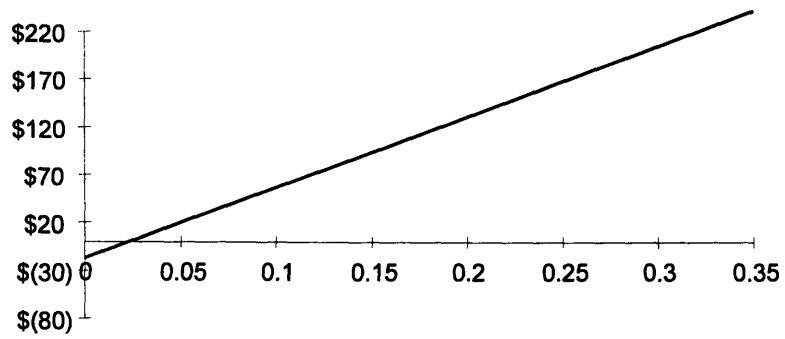


Figure B-4: NPV Change with Increased Gross Margin

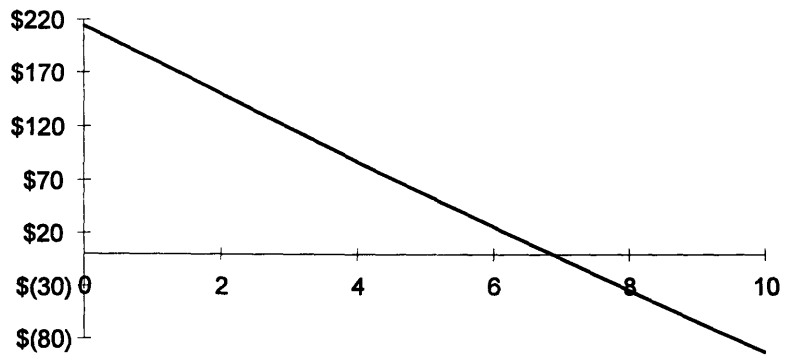


Figure B-5: NPV Change with Increased Weeks of Stock

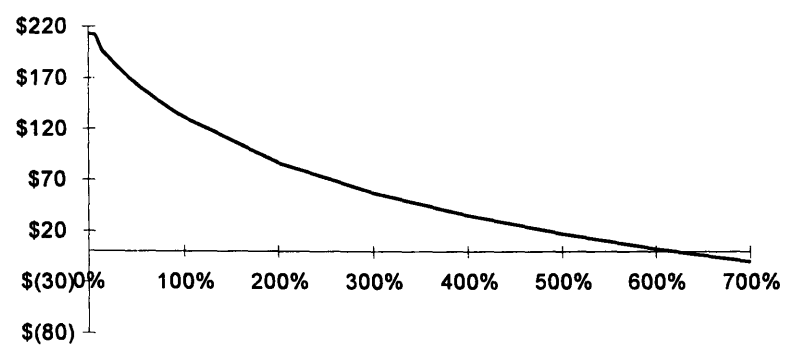


Figure B-6: NPV Change with Increased Monthly Depreciation Rate

The value of gross margin is immediately indicated through Figure B-4. There is a clear sensitivity of the attractiveness of this business model to the actual margin that the manufacturer is able to work with. With partnering as described, the break even point is approximately 2% gross margin.

Figure B-5 provides illustration that does not readily support the claim that it is undesirable to hold stock. This figure indicates that, all else remaining the same, the stock can be increased to almost 7 weeks while a positive NPV is maintained. However, the reason for this high level is directly related to the high gross margin of 30% that was worked with. If a gross margin of 5% is worked with, the maximum stock allowed is just under 1 week.

Figure B-6 displays the sensitivity of NPV to a change in the monthly depreciation, again with all else being the same. This figure indicates that with .3 weeks of stock, and 30% gross margin, slightly more than 600% monthly depreciation is allowed for a break even NPV. With a gross margin of 5% and .3 weeks of stock, the maximum monthly depreciation is 28%.

If the same sensitivity graphs are plotted for the non co-operative model of Figure B-3, the relative trends are observed, but to gain a positive NPV requires higher gross margins. This is the case since the non co-operative model numbers provide a negative NPV. If all else remains the same, the gross margin must be brought up to 36% to provide a positive NPV. Alternatively, if everything is kept the same and the weeks of safety stock is modified; it must be brought down to 6.8 before the NPV becomes positive. The final thing to note is that by lowering the monthly depreciation to 5%, the NPV becomes positive.

APPENDIX C: INVENTORY ANALYSIS

This appendix is used to establish a rough inventory approximation that will be used to help identify causes of inventory buildup in section 3.2.2. Included are the basic influence that many factors have on inventory.

General Relationship:

(Rosenfield and Pendrock, 1980) have described the relationship between safety-stock and number of warehouses. In their paper they discuss how safety stock is used to protect against uncertainty of demand and lead times while maintaining a desired service level. They go on to establish a proportional relationship.

They establish the fact that as the number of warehouses increase in a system, the more total system inventory is required. This is stated while realizing that the local stocks required actually decrease since each warehouse serves a smaller portion of the total demand. They then go on to establish the first order approximate relationship that safety stock required is proportional to the standard deviation of demand over the lead time.

The relationship between the standard deviation of demand over any time period and the portion of demand covered by an individual warehouse is then described to vary between the square root of the demand and the first power of demand. With this, the authors assert that the safety-stock in the system is approximately proportional to:

$$\text{Warehouse Safety Stock} \propto N \times (D/N)^\alpha = D^\alpha N^{1-\alpha}$$

In this relationship, N equals the number of warehouses and D equals the aggregate or total system demand. With demand generally meaning the number of units to be sold, or otherwise transferred to a customer. The exponent α provides the relationship between the standard deviation of demand and the actual demand. Rosenfield and Pendrock state that this approximation is used since the actual theoretical formulations cannot be established practically because of the information requirements and the assumptions underlying the theoretical formulations.

The authors go on to describe how the value of α has been empirically shown to be less than 1. Therefore, the amount of total system safety stock required increases as the number of warehouses increase.

There are several factors that influence this relationship that make an exact formulation unrealistic. Here is a list of issues that affect this:⁵²

⁵² Note: This list is not intended to be all inclusive.

- Variability of Demand - Is the distribution of demand evenly distributed by region/customer?
- Variability of Lead Time - Is there any variation in the amount of time required to procure materials, build a unit, and ship to the warehouse?
- Distribution of Demand - Is the demand evenly distributed by region/customer?
- Distribution of Lead Time - Is the lead time consistent for each customer?
- Fill Time Requirements - What amount of demand must be met from stock versus the amount that can be met from a build-to-order model?
- Service Level Differences - Could the service level requirements be different by segmentation of the demand?
- Correlation of Demands - Can the segmented regions easily share stocks?

What This Implies:

In the remainder of this appendix, the special case of a normally distributed demand scenario will be considered to help illustrate the inventory management challenges. The intent is to provide an appreciation for the relationship described by Rosenfield and Pendrock and to extend it to the concept of SKU proliferation and lead time. Since materials managers often use historical demand information to establish control policies, an appreciation for a general case should illustrate the overall challenges. The overall goal of this work is to provide a general relationship that can be used in section 3.2.2.

In section 2.4.3.2, five major categories of inventory are presented. These types include: staging stock, transit stock, cycle stock, safety stock, and obsolete stock. Other inventories include new product promotional inventory and customer returns. In this appendix, each of these will be described to illustrate how they may affect the system.

To provide this illustration, the assumption of a normal distribution of demand will be used. The first thing that will be described is what this means.

A simple approximation based on an assumption that demand is normally distributed:

Assuming:

1. A historical period demand is representative of the future (the expected demand and variance is the mean and variance of the historical sample). The demand is constant and not growing.
2. The demand is, and will continue to be, normally distributed.

3. The demand is independent from one period to the next (any demand not met during a period does not carry over to the next period and a high/low demand one week is no indication of what the demand will be the following week).
4. Inventory is not shared between warehouses or to satisfy alternate SKUs.
5. Division of the aggregate demand and variance leads to demands and variances that are proportionally smaller but are also normally distributed.
6. The lead time to one warehouse is the same to all warehouses.
7. Capacity is not a constraining factor.
8. Lead Time variability is insignificant.
9. No inventory is kept to hedge potential demand surges or for similar issues.

What is a normal distribution?:

When expected demand is normally distributed, the mean is equal to the median demand. In percentage terms, it is expected that 50% of the demand will fall below the mean and 50% will fall above the mean (see Hogg and Ledolter, 1987, for a more detailed appreciation of this subject). The demand corresponding to the peak height of the bell curve is equal to the mean, or expected demand. As shown in Figure C-1, the relative frequency of a specific demand in a normal distribution profile will vary relative to the classic bell curve.

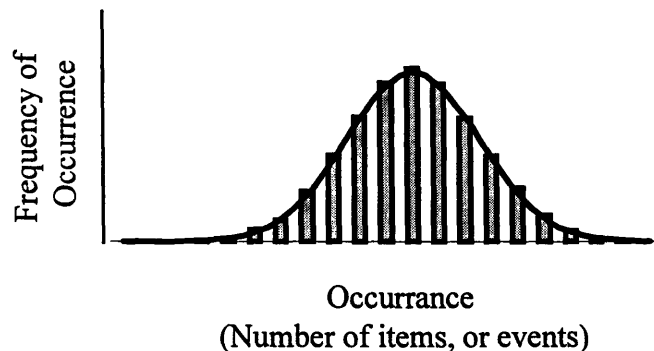


Figure C-1: Normal Distribution Frequency Histogram

Is this what Digital sees?:

If aggregate demand is analyzed, and a relative frequency histogram is plotted, see Figure C-2, there is a general appearance of being normal. However, it is very difficult to know from this whether the demand actually is normal. Determining this specifically is not the purpose of this section. The purpose is to use a normal distribution assumption to provide an understand of inventory management elements. The assumption that the

aggregate demand information presented in Figure 2-1 is normal will be considered for the remaining of this appendix.

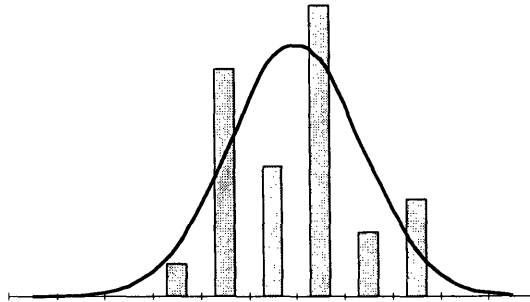


Figure C-2: Relative Frequency Histogram of Aggregate Sales to End User by Week (26 Weeks Observed. Bars Represent Relative Frequency of Occurrence)⁵³

Safety Stock

Safety stock inventory is required to provide satisfactory service levels in light of the variability in lead time and demand.⁵⁴ Safety stock can be used not only to maintain high service, but also to reduce the costs associated with a lost sale. The service level selected drives inventory by increasing the level of safety stock required in the system. The service level has two major components: time to fill an order, and percentage of orders filled within the desired time. For simplicity, the service level is assumed to be the percent of times that the actual demand is met by stock at the site, or the location where the interaction is being made with the customer.⁵⁵

Since it has been assumed that demand is normally distributed, statistics can be used to establish a safety stock required to meet a desired service level. Given the normal distribution relationship, if the service level is set to be less than or equal to 50%, the location would not have to maintain a safety stock (see Magee, Copacino and Rosenfield, 1985, for more detail on this). Figure C-3 provides an illustration of the overall relationship of service level to safety stock. The reader will notice that an extremely high safety stock is required to approach the 100% service level.

⁵³ Data not presented in magnitudes or actual volume-buckets to preserve proprietary information.

⁵⁴ Lead time here being the time to procure, make, ship and receive the unit at the distributor. For the purposes of simplicity, all calculations will assume that lead time variability is insignificant and will be conservatively set to nothing within the demand period increments. Addition of this element adds significant complexity that will not augment the overall understanding of the issues.

⁵⁵ There are other ways to consider service level (Nahmias, 1993). For the purposes of this report service level is the percentage of demand filled from stock within an allowable period to fill the order.

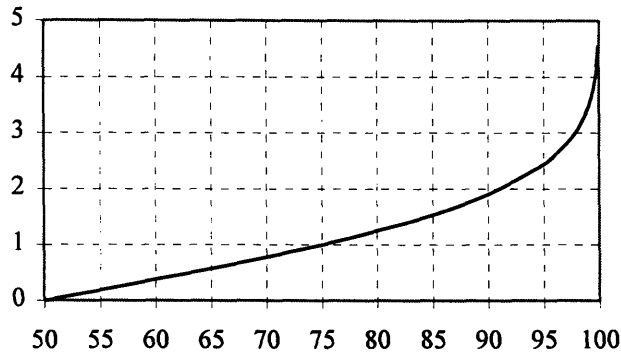


Figure C-3: Relative Inventory Required as Desired Service Level (%) Increases
(Relative Inventory on Vertical Axis)

As the service level desired is increased, safety stock must be added to the location to ensure that the demand can be met as required. The amount of safety stock required is a function of the normal distribution. If demand is normally distributed and independence is assumed, the safety stock required can be approximated with Equation 1. In this equation, σ represents the sample standard deviation of demand over the replenishment lead time and z represents a factor by which the standard deviation is multiplied by to maintain a desired service-level and $LT =$ lead time in number of demand period terms.⁵⁶

$$\text{Safety Stock} = z\sigma\sqrt{LT} \quad \text{Equation 1}$$

Equation 1 provides the simple safety stock formula. As the number of SKUs and the number of warehouses are increased, the relationship will be modified. The following sections are used to address these elements.

Observe:

Using $E(D)$ and (σ^2) as the one period expected demand and variance from one demand center respectively, with the assumptions stated, the following relationships apply:

Expected Demand of Multiple Periods or Demand Centers: $\sum_{i=1}^N E(Di) = N \times E(D)$

Variance of Multiple Periods or Demand Centers: $\sum_{i=1}^N (\sigma_i^2) = N \times (\sigma^2)$

Therefore, it should be interpreted that if a demand is normally distributed, and all the assumptions listed apply, a simple division of the aggregate demand into separate elements based on additional SKUs and Warehouses will not increase or decrease the total aggregate demand. The following section provides this in detail:

⁵⁶ See Hogg and Ledolter to understand z factor origins.

Multiple Warehouses or SKUs Considered:

Using $E(DNWH)$ as the 1 period expected demand per each warehouse in a N warehouse system and $(\sigma_{NWH})^2$ as the 1 period variance per each warehouse in a N warehouse system and (σ_{NWH}) as the 1 period standard deviation per warehouse in a N warehouse system, we can establish the following:

$$2 \text{ Warehouse Expected Demand is: } E(D2WH) = E(D1WH) \div 2$$

$$N \text{ Warehouse Expected Demand is: } E(DNWH) = E(D1WH) \div N$$

$$2 \text{ Warehouse Variance is: } (\sigma_{2WH})^2 = (\sigma_{1WH})^2 \div 2$$

$$N \text{ Warehouse Variance is: } (\sigma_{NWH})^2 = (\sigma_{1WH})^2 \div N$$

$$1 \text{ Warehouse Standard Deviation is: } \sigma_{1WH} = \sqrt{(\sigma_{1WH})^2}$$

$$2 \text{ Warehouse Standard Deviation is: } \sigma_{2WH} = \sqrt{(\sigma_{1WH})^2 \div 2} = \sigma_{1WH} \div \sqrt{2}$$

$$N \text{ Warehouse Standard Deviation is: } \sigma_{NWH} = \sqrt{(\sigma_{1WH})^2 \div N} = \sigma_{1WH} \div \sqrt{N}$$

And since safety-stock is established by multiplying the standard deviation by the service level factor, z, the total system safety stock is figured out by adding all the standard deviations and multiplying by the appropriate z factor.

$$\begin{aligned} \text{Total System Safety Stock with N Warehouse is: } & \left[N * \left(\sigma_{1WH} \div \sqrt{N} \right) \right] \times z \\ & = \left(\sigma_{1WH} \times \sqrt{N} \right) \times z = \left(\sigma_{1WH} \times z \right) \times \sqrt{N} \end{aligned}$$

Which establishes the approximation that the total system safety stock increases proportional to the square root of the number of warehouses in the system.

The same logic can be applied to the number of SKUs to give the same relationship (Using (σ_{1SKU}) as representing the 1 period standard deviation of demand with only 1 SKU considered):

$$\text{Total System Safety-Stock with N SKUs is: } \left(\sigma_{1SKU} \times z \right) \times \sqrt{N}$$

Which establishes the approximation that the total system safety-stock increases proportional to the square root of the number of SKUs in the system.

Increased Periods to Fill Considered:

The formulations described thus far are based on the assumption that the demand is met from stock. In situations where the demand can be met the next period, or multiples thereof, the amount of safety stock can be reduced. If the customer will be satisfied with having their demand met with the lead time, no safety stock is required. Here the impact of an extended period-to-fill (PTF) is established.

An extended period to fill, that is one that enables the demand to be met with some lead time that is less than the overall lead time. This may be a situation where the lead time is ten weeks, and a manufacturer can quote a wait of eight weeks. Situations like these may occur due to competitive pressures that make a ten week lead time unacceptable. In this case, the manufacturer will need safety stock and the amount of safety stock will be established using the standard deviation of demand over the difference between the lead time and the number of periods allowed. This safety stock relationship is represented here:

$$\text{Safety Stock (With Allowance)} = z\sigma\sqrt{LT - PTF}, \text{ if } LT > PTF$$

For this equation, PTF= the number of demand periods allowed to fill the order where PTF=0 represents the current period. This equation assumes that 100% of the demand is allowed a PTF period fill time. If there is a smaller proportion, the equation will have to be modified to accommodate.⁵⁷

In the case where demand can be met from production the overall safety stock required is:

$$\text{Safety Stock} = 0, \text{ if } (LT - PTF) \leq 0$$

The number of stocking-points, and the number of SKUs increase safety stock requirements approximately proportional to Equation 3. In this equation, N would be equal to the number of stocking-points, or the number of SKUs. Equation 4 shows how all the elements are related to form the final safety stock FSS; here WH represents number of stocking-points, SKU represents the number of variants, PTF represents the number of periods allowed to fill order, and LT represents the overall lead time. The general relationships of increasing warehouses or SKUs are illustrated in Figure C-4.

$$\text{New Safety - Stock} = z\sigma\sqrt{LT - PTF} \times \sqrt{N}, \text{ if } LT > PTF \quad \text{Equation 2}$$

$$\text{FSS} = z\sigma\sqrt{LT - PTF} \times \sqrt{SKU} \times \sqrt{WH}, \text{ if } LT > PTF \quad \text{Equation 3}$$

⁵⁷ This relationship will be very complicated to derive since it becomes confounded with many of the original assumptions. It is beyond the scope of this work to derive the relationship.

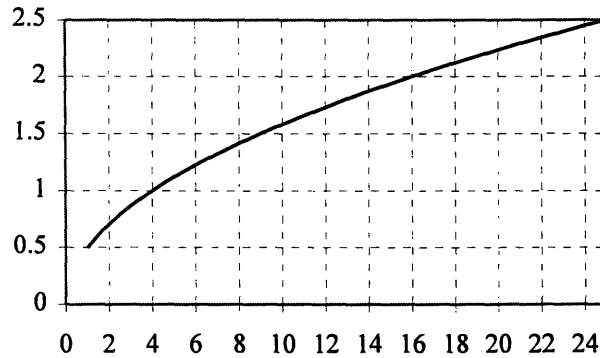


Figure C-4: Relative Inventory Required as Number of Warehouses or SKUs increase
(Relative Inventory on Vertical Axis)

Overall Safety Stock Conclusion:

If the three relationships stated are combined, the following approximation related to complexity can be used for generalization: Total system safety stock is:⁵⁸

$$f(SL, WH, PTF, SKU) \approx z\sigma \sqrt{WH} \sqrt{SKU} \sqrt{LT - PTF}, \text{ if } LT > PTF$$

Where SL = Service Level, WH = Number of Warehouses, PTF = Fill Time, SKU = Number of Stock Keeping Units, σ = standard deviation of demand over the lead time, LT=Lead Time.

It will be re-iterated that the relationship between safety stock and the number of SKUs has been established using assumptions of normal distributions of the individual variants and that the total demand is proportionally divided by the number of SKUs. Magee, Copacino & Rosenfield have stated that in practice, the demand for individual SKUs will often conform to a log-normal distribution. This fact can be generally supported by looking at the individual SKUs, but it is beyond the scope of this paper to work the specifics related to SKU proliferation; it is more relevant that the general relationship is understood.

Transit Stock

Another driver of overall finished goods inventory is concerned with the transit time, or time to replenish inventory in the distribution channel. The replenishment time is a function of transaction processing, production, procurement and shipping time constraints. The general relationship implies that the total system inventory will increase by the expected demand multiplied by the lead time.

⁵⁸ Again, all the assumptions must be true for this to be true.

Transaction Processing Elements

Transaction processing economics will also play a role in driving the amount of inventory in the system. Considerations here include the benefits of shipping full truckloads versus partial shipments. Also included are the costs of managing production lot sizes of one and related issues. For the purpose of simplicity, and since actual PC assembly times are relatively short, the issues related to transaction processing economics are considered to fall within the lead time management. They should not be ignored as irrelevant, they will be treated in aggregate form under lead time implications for simplicity. Staging stock, the finished goods in the factory waiting for shipment, will fall into this category as well.

Obsolete Inventory

Another driver of overall finished goods inventory is concerned with the amount of obsolete materials that are in the system. In the PC industry, due to the high rate of obsolescence, this can be a significant issue. There is no readily available method to determine the amount of obsolete inventory to expect.

New Product Inventory

One more element that impacts the level of inventory in the system is related to the introduction of new products, and the associated hedging of positions that various members take, or attempt to take. It is common for a manufacturer to stock extra materials in the distribution channel just prior to a new product introduction. It is also common for many very hot selling products to be put on allocation.⁵⁹ The exact implication of this issue on inventory management is also difficult to determine.

Trans-shipment Elements

Another area that impacts, or potentially benefits inventory levels would be the coordination of distribution activities. Consideration of this is generally intended to cover issues such as trans-shipment between distributors, and regional shipment coordination. Regional shipment coordination is partially considered in transaction processing economics, but has been highlighted due to its potentially significant benefits. There is no readily available formula to present this type of inventory impact.

⁵⁹ With allocation, the distributor is only permitted to have a certain percentage of the actual units produced to ensure all distributors have access. It can be a source of discontent with channel-partners.

Customer Returns

The final element driving inventory levels is related to customer returns. In the PC industry, customer returns are common. Returns come from both the end-user and the distribution partners. The amount of returns to expect is difficult to determine.

Final Relationship

When all the mentioned elements are combined, the total average finished goods inventory in the system over a demand period can be approximated using Equation 4.

In this equation, the following describes the variables: \bar{X} =The one period expected aggregate demand, WH =Number of warehouses or stocking-points in the system, SKU =Number of stock keeping units provided, $z\sigma$ =Aggregate safety stock, PTF =Demand periods allowed to fill order, LT =Lead time represented as the number of demand periods, Np =New product introduction or promotional inventory, Ob =Obsolete inventory, Ts =Adjustment for trans-shipments between stocking locations, R =Customer returns..

$$I \approx \left(\frac{\bar{X}}{2} \right) + z\sigma \sqrt{LT - PTF} \sqrt{WH} \sqrt{SKU} + (LT \times \bar{X}) + Ob + Np + R - Ts, \text{ if } LT > PTF$$

Equation 4: Finished Goods Inventory Approximation